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TRANSMISSION OF MESSAGES THROUGH THE AIR BY ELECTRICITY WITHOUT WIRES.

By John Trowbridge.

The popular hope that we shall be able to transmit messages through the air by electricity without the use of telegraph wires is supposed by some to indicate its realization at a future day. The impression may be a forewarning of evolution. Let us examine how near we are at present to the realization of this hope.

I suppose that the chief use of any method by which wires could be dispensed with would be at sea in a fog. On land it is hardly probable that any electrical method could be devised in which air or the ether of space could advantageously replace a metallic wire. The curvature of the earth would probably demand a system of frequent repetition, which is entirely obviated by the use of a metallic conductor. If, however, an electrical or magnetic system could be made to work through the air even at the distance of a mile, it would be of very great use at sea in averting collisions; for any system of signals depending upon the use of fog horns or fog whistles is apt to be misleading on account of the reflection of the sound from layers of air of different density and from the surface of the water. The difficulty of ascertaining the direction of a fog whistle or horn in a thick fog is well known. The waves of sound, even if they are carefully directed by a trumpet or by parabolic reflections, diverge so rapidly that there is no marked difference in the intensity between a position in the direct line with the source of sound and one far to one side. In Joseph Henry's experiments it was found that a sound moving against the wind, which was inaudible to the ear on the deck of a schooner, could be heard by ascending to the mast head. When the fishermen on the coast of Newfoundland hear the sound of the surf to the leeward, or from a point toward which the wind is blowing, they take the sound as an infallible indication that in the course of from one to five hours the wind will change to the opposite direction from which it was blowing at the time. The sound waves are already traveling on the upper strata of air with the changing wind.

A series of experiments by Tyndall with various sources of sound illustrated forcibly also the difficulty from aerial echoes. The human ear is not trained so accurately as the eye in perceiving direction. The experiment has been tried of placing a telephone beneath a person's chair without the person's knowledge and causing it by a powerful transmitter to give forth audible sounds. In most cases the hearer could not locate the position of the telephone in the room.

The most obvious method of signaling by electricity without the use of a wire is by electromagnetic induction. The subject of electrical induction is becoming the most important one in physics. It underlies the present method of transmitting human speech by electricity; the process for producing the electric light and the electrical power. It is not necessary for our present purpose to enter into a careful study of the subject of electromagnetic induction. Its most ordinary manipulations will serve our purpose. Suppose we have a coil of copper wire consisting of many turns, the ends of which are connected with a telephone. If we place a similar coil (Fig. 1), the ends of which are connected with a battery, within a few feet of the first mentioned coil and parallel to the latter, each time the current is made and broken in the coil connected with it, a current is produced by induction in the neighboring coil, which is connected with a telephone. This mysterious effect called induction, which takes place through the air between the coils and is only manifested for the instant during which the electrical current is changing in the coil connected with the battery—for it disappears when the electrical current becomes a steady flow and when the coils are stationary, and reappears the moment this current becomes fluctuating or when the coils are changing their position with respect to each other—is supposed to be propagated through the ether in waves. When the steady flow of the electric current is interrupted, the electromagnetic energy which is constantly coming to us from the sun—one of the manifestations of which is light—streams into the circuits which are near the battery circuit, to maintain the equilibrium which has been disturbed by the fluctuating energy of this battery.

Fig. 2.—TWO CIRCUITS TUNED TO ELECTRICAL UNISON.

Induction, therefore, can be looked upon as a transfer of electrical energy from point to point. We have an example of slow transfer of energy in the subject of radiant heat, which is now considered also a branch of electromagnetism. If the transfer of radiant heat from a hot iron ball to a piece of ice is a fluctuating transfer, the temperature of every conducting body in the neighborhood changes. If the radiation is constant, the temperature of the neighboring bodies, as far as they are affected by the radiation from the iron ball, also remains constant.

We are apt to think of these changes in temperature as slow in their appearance, and we marvel at the rapidity of electrical effects which we class together as effects of induction. The molecular changes produced, however, by what we call light and heat are extremely rapid, although the aggregate change may be slow in manifesting itself. A photographic plate will respond instantly to fluctuations of a light placed at a distance. A diaphragm closing the mouth piece of an ear trumpet will transmit to the air of the tube, and then to the human ear, changes of temperature produced in the diaphragm by throwing an image of the sun upon the diaphragm and then interrupting it 500 times a minute by means of a revolving wheel which is provided with a small opening. This apparatus constitutes the radeophone of Alexander Graham Bell.

I suppose we owe primarily our conception of the extremely rapid fluctuations of radiant heat to Balfour Stewart, who showed that when heat was reflected from a surface, all the molecules of the surface were set to quivering. If light and heat are electromagnetic phenomena, we should not expect any difference in velocity between the wave motions which manifest themselves as light and heat or as electricity.

To illustrate induction at a distance, Professor Joseph Henry placed a coil, five and a half feet in diameter, against a door, and at the distance of seven feet placed another coil of four feet in diameter. With a battery of eight elements, shocks were perceived when the terminals of the latter coil were held on the tongue and the battery circuit of the coil placed on the door was interrupted.

A similar experiment was tried by an early investigator following Henry, who used frogs' legs as an extremely delicate indicator of electrical induction. The legs were separated from the body of the frog, a portion of the lumbar nerve was exposed. One terminal of the wire connected with the induction coil was touched to the lumbar nerve, and the other to the calf of one of the legs. When the battery circuit was made or broken, the frog's legs spasmodically separated.

Later investigators are in the possession of much more refined instruments for detecting the effect of electrical induction. We must, in considering Henry's claims as one of America's greatest scientific men, remember that he had no insulated wire, which now is at the command of even boys who are experimenting in electricity. He was obliged to wind his wire with strips of cloth, and he had imperfect galvanoscopes or instruments to detect electrical effects. The modern galvanometer in the physical laboratory of Harvard University is affected by the circuit of the electrical car system, although this circuit is distant at least five hundred feet. It is violently affected by touching one of the wires leading to it to the top of the tongue and the other to the side of the tongue, thus showing a difference of chemical condition which it would be difficult to make manifest by the most refined chemical analysis.

It is probable that if Henry had been in possession of a modern mirror galvanometer, such as can now be found in every electrical workshop, he would have greatly extended his researches upon induction.

The method of electromagnetic induction has been used to telegraph from moving trains. In one of the methods a great circuit of wire is stretched in a car. One side of the windings of this circuit is placed as near as possible to the track; between the rails is placed an insulated wire. Morse signals, such as are employed in ordinary telegraphy, which are sent over this wire can be heard by induction in a telephone connected with the windings in the car.

These messages are sent through the air space between the wire on the track and the windings of the circuit in the train. In the latest forms of this method of communicating with a moving train, messages can be received on the train or sent from the train, by means of induction between a circuit in a car and a wire which is stretched on poles like an ordinary telegraph wire, beside the track.

Fig. 1.—APPARATUS FOR ILLUSTRATING ELECTRICAL INDUCTION.

Fig. 3.—SIGNALING WITHOUT WIRES.

In all these methods in which electromagnetic induction is successfully employed, the coils or windings which produce an electrical disturbance in a neighboring coil, by means of a current flowing in an intermittent manner through them, are never more than ten or twelve feet apart.

Suppose that a wire is stretched from yardarm to yardarm, over the top of the foremast of a steamer, thus outlining, so to speak, the square rig of the sails. Let the wire be passed ten or twelve times in a cable in this manner, and the ends finally connected with a powerful battery or dynamo. Let another steamer have a similar arrangement. As it approaches the first mentioned steamer, A, suppose its battery is disconnected and a telephone is inserted at the ends of the coil of wire which passes around the foremast. If the current in the coil on steamer A is broken, a click will be heard in the telephone, if the steamers are sufficiently near each other. If the current is broken rapidly, a musical note corresponding to the rate of the break will be heard in the telephone. This noise will be strongest when the coils on both steamers occupy a certain definite position in relation to each other. If, therefore, the coil upon which the telephone is placed is capable of revolving, the position of the coil on steamer, A, and therefore that of the steamer, A, can be ascertained.

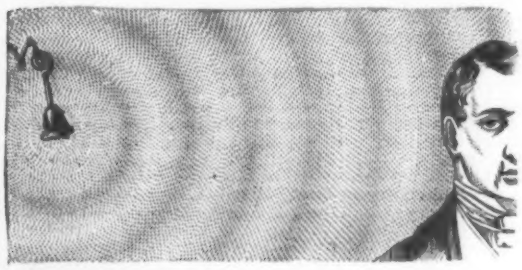


Fig. 4.—SPREADING OF SOUND WAVES.

This may be called the method by electromagnetic induction, and nothing seems simpler. Each steamship would be provided with similar apparatus, dynamos which could be switched in when the observer is not listening, and telephones which could take the place of the dynamo when the observer wishes to listen.

Unfortunately, a simple calculation shows that under the best conditions of strong currents and suitable resistance of the coils to the passage of electricity the size of the coils would have to be enormous. I have computed that to produce an audible note in the telephone when the coils on the steamers are at a distance of half a mile and the steamers are approaching each other bow on—the most favorable position for hearing the note—a coil of ten turns of a radius of at least 800 feet would be necessary. In studying this question an interesting phenomenon will be noticed. If an ordinary Bell telephone, not connected with any wires, is held to the ear, and is pointed while thus held toward the coil through which the current of electricity is being interrupted, the noise of breaking and making the current can be heard in the telephone. If the little coil of wire in the telephone is removed, the noise is still heard in the telephone. It is evidently due to the fluctuations of magnetism in the magnet of the telephone. These fluctuations set the iron disk of the telephone in vibration, and thus the changing currents in the distant coil are heard in the telephone. These fluctuations can be heard in such a magnetic telephone—if it is held to the ear—while the approaching steamer, provided with a coil of 800 feet radius, through which a current capable of maintaining 500 incandescent lamps is rapidly made and broken, is still half a mile off in a direct line with the bow upon which the observer supplied with the telephone is placed.

It is evident that a coil of this size would be out of the question. Instead of increasing the size of the coil beyond the practical limits of the masts and yardarms of the steamship, one can increase the strength of the electrical current which is caused to alternate or vibrate through this coil, and thus produce magnetic fluctuations at a distance of half a mile. Calculations, again, show that the strength of the current would have to be beyond a practical limit, unless we discover some method of tuning, so to speak, two coils so that electrical oscillations set up in one may be transmitted to a distant circuit which has been put in electrical unison.

This subject of electrical unison, or resonance, has attracted great attention during the last two years, and can be illustrated in various ways. Suppose that we connect a well insulated coil on large radius and ten or twelve turns of wire with a charged Leyden jar. A spark will pass when one end of the coil is connected with the inside of the jar and the other end with the outside of the jar. In other words, the charge in the jar is discharged through the coil. Place a coil of exactly the same size and exactly the same number of turns (Fig. 2) near and parallel to the first coil, and bring its ends very near to each other. No indication of an electrical disturbance will be noticed at these ends until one end of the coil is connected with the inner coating of a Leyden jar of exactly the same size as that in the disturbing circuit and the other end with the outside of the same jar. The two circuits have then the same electrical capacity and can be said to be tuned in unison with each other.

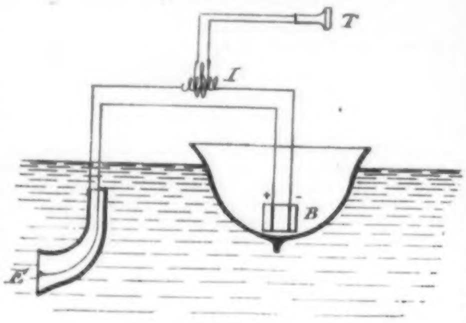


Fig. 6.

When the tuning is exact, a small spark will pass between the ends of the second coil at the instant the charged jar connected with the terminals of the first coil is discharged. This effect can be easily perceived between coils placed five feet apart which are six feet in diameter, of ten or twelve turns of wire. The distance at which it can be recognized depends upon the size of the coils and the amount of electricity with which the Leyden jar is charged. The effect is the greatest when the coils are parallel. It will be noticed that this is the experiment tried by Joseph Henry, to whom we have already alluded, with the addition of the idea of electrical resonance.

It is possible that some method may be devised of rendering electrical oscillations sensible to the eye or ear through great distances without the use of a wire. At present we are practically limited to distances of a few hundred feet.

Since we have, apparently, little to hope for from electromagnetic induction signaling through a fog, cannot we expect something from what is called static induction? This form of induction can be well illustrated by an experiment of Joseph Henry. An ordinary electrical machine was placed in the third story of a house, and a metallic plate four feet in diameter was suspended from one of its conductors. In the first story of the house, twenty-five feet below, in a direct line was placed a similar disk of metal, which was well insulated.

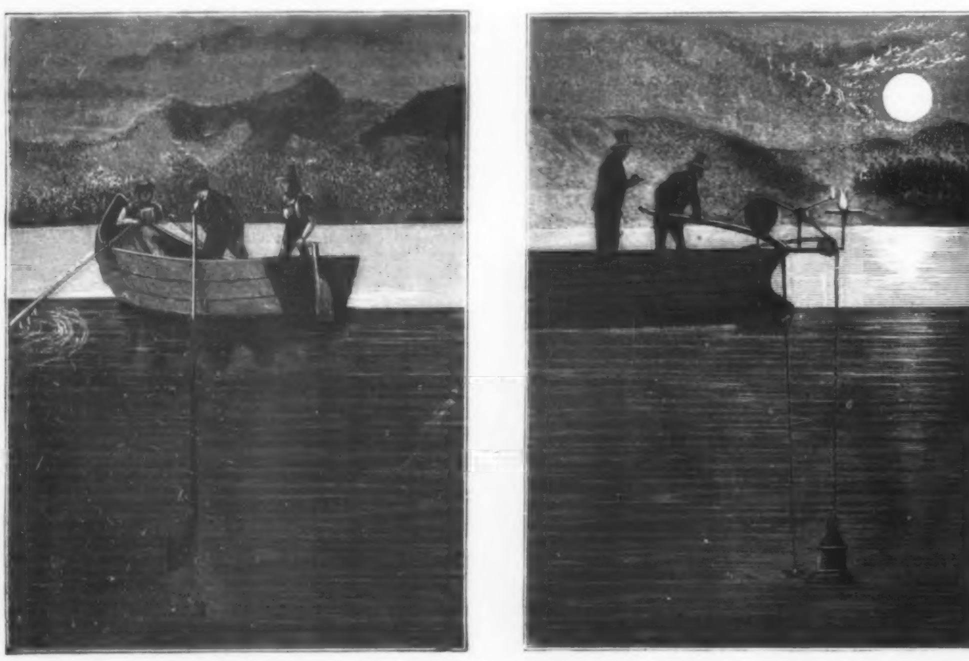


Fig. 5.—APPARATUS FOR MEASURING VELOCITY OF SOUND UNDER WATER.

When the disk connected with the electrical machine was electrified, the disk in the lower story of the house also showed electrification. A pith ball electrified positively was attracted or repelled by it, thus showing that the inductive influence extended through the floors. The distance to which this electrical influence can be extended depends upon the charge that can be given to the influencing plate and upon its dimensions. If one should erect an enormous carefully insulated and highly charged metallic plate on a hill, it is probable that its electrical influence could be felt to the edge of the horizon. The size of the plate and the available charge that could be given it does not, at our present writing, make this a practical method of conveying intelligence through the air by electricity without the use of wires.

During some experiments in England it was found that messages which were transmitted on a line passing through Newcastle were heard at Gretna on a parallel line, the distance between the lines being forty miles. I am inclined to believe that these messages were not transmitted through the air by induction, but were the effect of leakage through the earth from one line to the other. In Cambridge, at present, one hears in the telephone connected with wires which are at a considerable distance from the overhead system of the electric railway, the noise of the generators which supply the current for the motors. It is probable that most of this disturbance does not come through the air between the telephone wires and the overhead system of the electrical pathway, but is due to leakage from the earth connection of the electrical railway.

A consideration of this problem of leakage will lead us to another method of signaling by electricity without wires. Take a tumbler. Fill it to a suitable height with a solution of bichromate of potash which has been made with sulphuric acid. Place in this tumbler a strip of zinc and a rod of carbon. We have thus made a voltaic battery. Connect the piece of zinc by means of a wire with a sheet of metal or a board covered with tin foil, and connect also the rod of carbon by means of a wire with this sheet of metal. Let the points on the sheet of metal which are touched be about two feet apart. Then, holding a telephone to the ear, touch different points of the metallic plates with the ends of the wires running to the telephone (Fig. 3) and break the connection of the battery with the plate. A click will be heard in the telephone, when the battery circuit is interrupted, unless the terminals of the wires running to the telephone happen to be at points between which there is no difference of electrical level.

Let, therefore, steamer A be provided with a powerful dynamo. Connect one terminal of the dynamo with the water at the bow of the steamer and allow a long wire, insulated except at its extreme end, to drag over the stern, being buoyed up so as not to sink. The current from the dynamo will then pass into the water and return, so to speak, to the dynamo. Suppose that the current is interrupted suitably at least one hundred times a second. Let the approaching steamer be provided with a telephone wire, the ends of which touch the water at the bow and at the stern. A telephone in the circuit of this wire will respond to the interruptions of the dynamo circuit, and by interrupting the alternations of the dynamo circuit according to the Morse alphabet, which is commonly used in telegraphy, one steamer could communicate with another. Both steamers could be provided with duplicate apparatus. When the observer on steamer A desired to listen, the interruptions of the dynamo current on steamer A could cease.

This method can be characterized, in popular language, as a process of saturating the water with electricity. If any passage is offered to this electricity through a wire which connects to points on the water which are at different degrees of saturation, an electrical flow is established through this wire. Then the wire connected with a telephone receives a current which actuates the telephone and passes back into the water. In scientific language it is said that a current will flow into any conductor whose ends are at different electrical levels—just as water flows from a higher level to a lower level.

Thus the water of the ocean, in the neighborhood of the ends of the wire connected with the dynamo machine on board the steamship, is maintained by the action of the dynamo at different electrical levels; and this inequality of level exists over a large area in which the ends of the dynamo wire are immersed. The success or failure of this method of communicating between steamships in a fog depends, therefore, upon the distance between the ends of the dynamo wires which are immersed in the water and upon the strength of the current which can be maintained at these ends.

A few years ago some students, studying in the Physical Laboratory of Harvard University, made, under the writer's direction, an electrical survey of the extent of area influenced by the earth connections of a battery of from ten to thirty voltaic cells connected with the time service of Harvard College Observatory. One end of this battery was connected with the ground at the observatory and the other end with the ground in Boston, which was distant about four miles. It was found that the time signals could be heard in a telephone connected with the gas pipes of a house a quarter of a mile from the observatory end of the battery, and with a spring of water six hundred feet from the gas pipes in a direction away from the observatory. These time signals were produced at the observatory by breaking and making the electrical circuit of the battery.

At a distance of a mile from the observatory the signals could be heard when the gas pipes of one building in the college yard were connected by a wire, through a telephone, with the water pipes in an adjacent building—the water pipes and gas pipes being fifty feet apart.

It was evident from this survey that the great circuit of the gas pipes and water pipes throughout the city of Cambridge was maintained at differences of electrical level by the battery at the observatory; and that time signals from the observatory could be obtained over a large area by simply connecting a telephone with the gas pipes and water pipes at points suitably distant from each other.

Shortly after these experiments were made, W. H. Preece, Esq., of the English telegraphic service, informed me that he had succeeded in transmitting Morse signals, by the method we had used in Cambridge, from the Isle of Wight to the English coast, through the water, a distance of at least eight miles, the ordinary method of communication, a submarine cable, having become temporarily disabled. Some years later Professor Alexander Graham Bell tried a similar experiment on the Potomac and confirmed our results.

It is probable that a dynamo capable of maintaining one hundred incandescent lamps could establish a

sufficient difference of electrical level between the water at the bow of steamship A and the end of a wire connected with the dynamo and trailing at a distance of half a mile behind the steamship to affect a telephone circuit suitably placed on steamship B, when the latter is still half a mile away from steamer A. The signals, however, at the best would be faint, and would be difficult to hear in the noise and commotion on board ship.

In studying the possibility of electrical communication between steamships without the use of a wire, I was led to try the direct transmission of sound through the water and the conversion of the sound waves into electrical pulsations or waves at the hearing station. It is well known that sound travels much faster in water than in air. A diver under water can hear the stones click together at distances between his ears and the stones far greater than those between which the same sound could be heard in air. The hearing distance is four or five times greater under water than in air. In an early experiment upon the velocity of sound in water, Colladon and Sturm caused a bell weighing half a ton to be struck by a hammer weighing 18 lb. under the water of Lake Geneva, and an observer at a distance of twenty-two miles, provided with a species of ear trumpet, the flaring end of which was under water, heard the sound. The difference in time was noted between the signal indicating the instant the bell was struck and the arrival of the sound through the water. It was found that the sound traveled through the water four times faster than through the air, its speed being about one thousand feet per second. Water therefore is a much better medium for the propagation of sound waves than air, and sound can be heard much farther through it than through air.

My method of experimenting was as follows: An assistant provided with a bell which could be sounded under water was stationed at one point while I proceeded in a boat to a distance and lowered a thin diaphragm similar to that employed in telephones, to the center of which was affixed a transmitter similar to those employed in the ordinary telephonic service (Fig. 6). It was hoped that the sound waves through the water might affect the transmitter and thus be changed into electrical energy. The advantage of using a transmitter over Colladon and Sturm's ear trumpet consisted in the ease with which the sound, if it could be heard at all, could be transmitted to any suitable hearing station on board the steamship; whereas a listener at the ear trumpet would have to be lowered over the side of the vessel and be obliged to listen at the risk of being immersed in the water.

The sound of the bell could be heard through the water considerably farther than through air with the unaided ear. The experiments, however, were not entirely satisfactory. A mile seems to be the limit of this method, even when sources of sound more powerful than a bell are employed. Another method to establish communication between steamers at sea would be the employment of small electromotors, which could propel little screw patrol boats, the direction of which could be regulated by electricity. Such patrol boats would require insulated wires which would serve to transmit the electrical current from the steamers to such boats, and thus to propel the boats and to keep up communication with the steamer which might send them out. If the sea was too high to permit sailors embarking in such boats, smaller ones provided with electric lights could be sent out in advance of the steamer. The contact of these boats, which might be termed finders, with a vessel or with an iceberg, might be discerned on board the steamship laboring through a dense fog.

Electricity is a flexible agent, and a machine actuated by it can be made through wires to perform functions which are almost human. The last method of extending the safe area in front of a steamship, although fanciful at first sight, seems the only practical one at present.

The electrical stimulus applied to paralyzed limbs more nearly resembles the vital stimulus than any other agent used in medicine. It seems as if it afforded man the opportunity to extend his nerve centers over immense areas, to reach out an electrical hand through the fog and feel the way or to hold a lantern far in advance to warn an oncoming steamer of another that is laboring in the darkness. We have in electricity an agent that can give us power, light, and sound at a distance of four or five miles from the position where the human observer directs his electrical self.

Still another method of transmitting intelligence through the air by means of electricity without the intervention of wires is by the use of the search light. Although this method consists in the employment of a light, the light is produced by electricity, and hence without a great stretch of terms the method can be called an electrical one. By directing a powerful beam from an electric light, which is placed at the focus of a parabolic mirror upon banks of clouds, and suitably interrupting its indications, one can transmit intelligence on a clear night to great distances. It is probable also that a sufficiently great luminosity could be caused on the upper layers of a medium fog to herald the approach of one steamer to another at a sufficient distance to prevent a collision.

To a traveler seated in the saloon of a great ocean steamer slowly finding its way through a blinding fog, any method that will take the place of the despairing wail of the fog whistle would be heartily welcomed. The possibilities of electricity would seem greater possibly to a person thus situated than to a dispassionate and comfortably situated person on shore with a wide and safe horizon around him.

ELECTRIC MOTIVE POWER ON ELEVATED RAILWAYS.*

By WILLIAM NELSON SMITH.

INTRODUCTION.

THE electric motor was, soon after its invention, applied to locomotion, and its development in this direction has always been an attractive problem for engineers.

It is hardly five years since the electric street railway became established on a commercial basis, and its progress in that time has been exceedingly rapid.

But the street railway has received the almost undivided attention of those interested in electrical locomotion, and aside from a few experiments, for they can hardly be called anything more, very little has yet been done in applying electricity to more general railway work. There has been a unanimous call for city and suburban rapid transit on the ordinary street railways, in cities all over the country; and those to whom we are most indebted for the recent advances in this direction have had, for this reason, but little time to devote to the more general application of electricity to long lines of railroad, all of which are now operated by steam locomotives. But several able engineers have, despite other and more pressing calls upon their time, made experiments in the operation of steam railroads by electrical motive power. Although it cannot as yet be said to have passed out of the experimental stage, enough has been done to show that we need not shrink from the problem that it brings before us, either in the design of plant and rolling stock or in cost of construction and operation.

The problem of applying electricity to the operation of street railways having been successfully solved, it is quite natural to look toward the elevated steam railway as the field in which next to test the capabilities of the electric motor, if it can be further developed as a means of locomotion. It is, so to speak, the first step beyond the street car; and if electricity can be economically applied to the solution of the vexed problem of rapid transit that now confronts some of our largest cities, it is safe to say that its general adoption upon the steam railroads may be ultimately looked for.

The object of this thesis is to indicate, first, the best method of applying electrical motive power to elevated railways, so far as the writer is able to judge; second, the general design of the electrical machinery required for the operation of the roads proposed in Chicago; third, an estimate of the cost of such installation, and a comparison of the cost of steam and electrical operation.

Before going farther, it may be of interest to look at what has been already done in this line.

HISTORY.

It is not the writer's purpose to sketch the history of electric railroading except in so far as it applies to this particular branch of the subject.

Mr. Stephen D. Field was the first to conceive of the application of modern dynamo-electric machinery to the railway. He applied for patents early in 1880. In 1881 he had a road in operation at Stockbridge, Massachusetts.

Mr. Thomas A. Edison was also experimenting in the same direction at about this time, and applied for patents not long after Mr. Field. Edison, in 1880, built a railway somewhat less than half a mile long, near his laboratory at Menlo Park, New Jersey.

The Siemens Brothers, of Germany, also experimented with the electric railway, but though they were not far behind in point of time, their work was subsequent to that of the two American inventors. Of these two, Mr. Field was eventually awarded priority, but the two interests were soon after consolidated.

Shortly before the opening of the Chicago Railway Exposition in 1883, it was proposed to build and operate an electric railway, which should be one of the features of the great display of railway appliances. In the short time given for the completion of this task, it was impossible to design special machinery for the purpose, so Messrs. Edison and Field had to adapt to their use such electric machinery as they could easily obtain. Generator and motor were Weston shunt machines. The locomotive, of course, had to be built to the motor. The track was of three foot gauge, and about a third of a mile in length, with two curves of fifty-six feet radius. A central rail brought current to the motor, and the track was used for the return. This locomotive, "The Judge," was the first ever operated in this country for business purposes. This was in June, 1883. While on exhibition, it ran 446·25 miles, and carried 26,805 passengers.

The success of Mr. Leo Daft's experiments, in 1883, began to attract some attention. After some preliminary trials his motor, the "Ampere," was run on the Saratoga and Mount McGregor Railroad. Being too light for its work, it jumped the track on a curve, but otherwise its performance was satisfactory. Its actual performance consisted in hauling an ordinary railway car weighing ten tons and containing sixty-eight persons, in addition to the motor itself, which weighed two tons and had five persons on it. The speed attained was eight miles per hour on a track having a grade of ninety-three feet to the mile. The maximum duty was about 12 horse power.

In 1884 Mr. Daft continued in the same line, equipping small roads at Coney Island, at the Mechanics' Institute Fair in Boston, and at the New Orleans Exposition. In 1885 he equipped two miles of street railway near Baltimore, using the central rail system of distribution, with ground return, and a separate locomotive.

In the same year, Mr. Daft began experiments on the Manhattan Elevated Railway, of New York City. His electric locomotive, the "Benjamin Franklin," was designed for seventy-five horse power and a normal speed of eighteen miles per hour. It weighed nine tons and was about fourteen feet long. A number of runs were made with it, but it seemed too light for its work, and was rebuilt. In October, 1888, Mr. Daft began a new and more elaborate system of trials, the weight of his motor having been increased to ten tons. The results of these experiments, in part, have been published in the transactions of the American Institute of Electrical Engineers, Vol. VI., No. 10 (October, 1889).

The mean speed attained was, with a three car empty train, about twenty-three miles per hour, and Mr. Daft claims that on a level he attained twenty-eight miles per hour. With a train of four Sixth Avenue cars, each weighing fifteen tons, plus the motor, weighing ten tons, a mean speed of 18·15 miles per hour, with a maximum of 25·24 miles, was attained, and the mean I. H. P. at the power station was 129·3. Mr. Daft does not publish any statements as to the exact efficiency of the system. From experiments subsequently conducted by the engineering department of the railway company, this was found to be rather low, particularly at the instant of starting.

The problem had also been attacked meanwhile by Mr. Frank J. Sprague, who made some experiments on the Thirty-fourth Street branch of the Third Avenue line of the Manhattan Railway. Mr. Sprague went at it in a somewhat different way. Instead of having a regular electric locomotive, he adopted the plan of putting the motors in the trucks of a car, thus utilizing the entire weight of car and passengers for traction. Having devoted all his attention to the development of the electric motor, Mr. Sprague had worked out some very interesting facts, which he was enabled to apply in these experiments. Chief among them are the method of flexible suspension of the motors, centering them on the axle and giving them resilience by means of springs; the varying of the output by strengthening or weakening the magnetic field in inverse proportion to the power demanded; and the system of electric breaking which became available, when using the shunt-wound motor, by converting the motor into a dynamo and using the train's kinetic energy to restore electrical energy to the line, this performance of work by the train tending of course to stop it. Mr. Sprague claims to have obtained in this way a return in electrical energy of sixty per cent. of so much of the train's kinetic energy as he was able to use, or about eight-ninths. The use of ordinary brakes was thus made unnecessary, and by simply varying the field strength, he was enabled to handle his train very easily. Owing to the limit to which his strength of field may be carried, it becomes necessary to close the armature on a local circuit when the speed had been reduced about two-thirds, as the peripheral velocity of the armature was then too low to raise the armature potential above that of the line. As for the remainder of the energy of stopping, Mr. Sprague proposed to employ it in heating the cars.

Since the above experiments were made, Mr. Sprague has designed a 300 horse power motor car, which will be considered later. Mr. Stephen D. Field, two or three years ago, designed and built an electric locomotive, which was tried on the Thirty-fourth Street branch of the Manhattan Railway. The chief peculiarity of this machine consisted in the size of the armature and its mode of connection to the drivers. Cranks were keyed to the armature shaft at each end, and the crank pins each took hold of the middle of a side rod, each end of which was attached by a crank pin to a driving wheel, as in the ordinary locomotive. The grade on this branch is quite steep, and the usual load for a locomotive is only one car. Mr. Field's motor weighed about 13 tons, and hauled the coach up the grade at a speed of about eight miles per hour, and required about 38 electrical horse power.

At present, very little is being done in this country to advance the "state of the art." There is at Sunbury, Pennsylvania, a short line of railroad operated by electricity, a sort of connecting link between two roads, both freight and passengers being hauled. In England, a new system of underground railways in London is being operated by electricity, a speed of 30 miles per hour being attained.

So far as the writer is aware, these few examples constitute all that has been done as yet toward the substitution of electrical for steam motive power. At present there are about 250 street railways operated electrically, while only the two last mentioned lines have substituted electricity for steam.

But despite the conservatism of the railroad managers, there are not wanting engineers who are convinced that the extension of the electric motor into territory now occupied by steam is not a really difficult problem.

It is encouraging to note that, at the present time (May, 1890), the West End Railway Company, of Boston, is endeavoring to obtain permission to build a line of electrical elevated railway for suburban traffic, to supplement their large system of electric street cars in that city. And in Chicago there is a provision in the charter of the West Chicago Rapid Transit Company that electricity may be used as a motive power. The manager of the Manhattan Railway Co., Colonel Hain, told the writer that they would change their system to an electrical one the moment they were satisfied that it could be so operated without being subject to any liability to accident or to unusual losses in economy of operation. There seems to be a growing sentiment among engineers that at no very distant day the electric motor will be applied to the elevated systems, but it is not likely that the Manhattan Company will adopt it, until it has first been proved successful somewhere else.

GENERAL CONSIDERATIONS.

There are three methods of applying electricity to the propulsion of a train. First, using an electric locomotive independent of the rest of the train, as in steam practice. Second, placing a motor in one or both trucks of each car, and controlling them from a single point. Third, a combination of the above methods, using a motor car, which will accommodate passengers, with motors in the trucks.

While undoubtedly advisable for use on solid ground, the first method, in elevated railway work, offers no advantage over the steam locomotive beyond perhaps a decrease in fuel expenditure. The electric locomotive must be nearly as heavy as its steam predecessor in order to handle the train, and this does not relieve the structure of the shocks due to the concentration of eighteen to twenty tons in a space of twelve to fifteen feet.

While the members of a truss may be perfectly able to withstand these shocks, the punishment they receive is found to have a tendency to loosen the rivets, and this constitutes the principal source of danger. Hence if we desire to increase the weight of trains, the locomotives must have a corresponding increase in weight. But this will necessitate increased strength of the structure, and will increase the wear and tear. So if this, which is not the least important of all the considerations, is to be taken into account, we cannot safely adopt the separate locomotive.

The second method, of placing motors under each car, while it may be practicable, will probably not be used on any extended scale on account of the greater cost and less efficiency of a large number of small motors, as compared with a smaller number of large ones of equal aggregate power. Besides, the entire weight of the train is not necessary for traction, only a third or fourth of it being required, so that this would be really unnecessary. The difficulties of handling all the motors simultaneously, the extra cost and the decreased efficiency, are all against this method.

The third method is that proposed by Mr. Sprague

* A thesis read at Sibley College, Cornell University, May, 1890.

to meet the existing conditions of traffic on the Manhattan Railway. His plan is to place powerful motors in the trucks of a car constructed for the purpose, not differing greatly in general dimensions from the ordinary car. The total available horse power is three hundred, or one hundred and fifty per truck. Each truck has two motors, of peculiar construction, and the motors are centered upon the axles, supported for the most part by them. The axles are five inches diameter and the wheels are forty-two inches. Each motor is of seventy-five horse power, and has two armatures. The car is like an ordinary elevated car, save that the platforms are closed in and the floor framing raised for about ten feet from each end, over the trucks. These spaces are partitioned off inside the car, each as an engineer's room, with duplicate operating mechanism in each, so that the car can be run from either end. Over the trucks are trap doors with heavy glass panels, which permit of easy inspection of the motors at any time.

The space in the center of the cars is given up to passengers, and has side doors for their ingress and egress. This car will have a tractive effort of twenty-thousand pounds and should be able to take care of any train on the Manhattan road very easily. This motor car is designed to meet the conditions of traffic as they exist at present. It has the advantage of spreading the weight that is necessary for traction over a large distance, thus relieving the structure, and at the same time it has motors which are large, reasonably efficient, and easy of inspection, and part of the paying load can be utilized for traction. Mr. Sprague prefers, however, the use of small train units, say of two cars each, which would enable them to be started and stopped rather more easily than in the case of large trains.

By the system of electrical braking which he put into practice a large proportion of the trains would, at any instant, be restoring energy to the line. The more frequent the trains, the more frequent are the stoppages, and the more marked is this advantage.

The method which the writer would advocate would be to run three-car trains, and make one of these cars a motor car, similar to Mr. Sprague's plan above mentioned. The motors would not need to be excessively heavy, for a train of this size, and taking everything into consideration, I should consider this about the most economical size of train for traffic of this kind.

In this discussion no mention has been made of the storage battery. As is well known, its excessive weight is prohibitory at the outstart, though by careful experiment this has been recently reduced. While used to some extent in street railway work, and possessing advantages over any other method of propulsion in streets which are very crowded, all that can be as yet said of it is that while it has succeeded in reducing operating expenses from those incurred in the use of horses, it has not yet arrived at the point where it could successfully compete with the steam locomotive, least of all on an elevated railway. While many are sanguine of its ultimate success, and receive occasional encouragement, it is not likely that it will ever be used in elevated railway work until its weight has been reduced even below that which might permit its use on or below the surface of the ground, as a substitute for the steam locomotive. We may, therefore, in considering the elevated railway problem, feel perfectly justified in leaving the storage battery out of the question.

The only other way of obtaining electrical power is by transmission from one or more central stations. The system may be operated in two ways: First, by constant current, and second, by constant potential distribution.

The constant current or "series system," as it is generally called, has been tried with fair success, in operating street railway cars. Its main advantage is in the fact that its use necessitates a "block system," and two trains could not approach nearer each other than the length of a block. The principle of electric braking would also become available. But unless a rather large current were used, this system would necessitate either excessively high potentials, or a multiplication of power stations, and any accident to a motor or its connection might be detrimental to the operation of the remainder of the cars in the same circuit.

This system has been developed by Mr. Sidney N. Short, of Cleveland, Ohio. Although in the future it will probably become better known than now, the writer would not make the attempt to apply it on a large scale at present. We will, therefore, consider distribution at constant potential.

The circuit may be arranged in three ways: First, by double overhead system; second, by a conduit or third rail system, on the road bed, with the rails as the return circuit; third, a single overhead wire, with return through the track.

The first of these methods is rather cumbersome, involving twice as much copper as the third, and a larger, heavier, and more complicated trolley. The second may be better, but is inconvenient by reason of the position of the conductor, which must be broken at every switch, turnout or crossing, and is in the way of the trackmen. It is also likely to be a great source of loss in wet or snowy weather, as insulation is then a difficult if not an impossible matter. But the overhead system with rail return saves copper, diminishes leakage, as it can be quite thoroughly protected, is out of the way, is not interfered with by switches, etc., but is a help in such matters instead of a hinderance. The method of rail return has another great advantage, in a double track system, for it permits the adoption of a three-wire system, using the tracks as the third wire. This effects a great saving in copper, and is as practicable as in the incandescent lighting. The only objection in the present case would be that to double the potential difference between the two main conductors would necessitate extra care in insulation.

The speed at which cars should be run depends somewhat on circumstances, the train intervals and the distance between stations being factors in the question.

In New York, the maximum is not much over 20 miles an hour, and the average, including stops, is only 11 or 12 miles. In Chicago, the Lake Street road will run at a maximum of 30 miles, an average, probably, of about 18 or 20, including stops. The South Chicago and the West Chicago roads have a maximum of 25, and will probably average 15 or 16 miles.

The peripheral velocity of the armature should also be taken into account for a given motor, as it is not best to exceed the original value for which the machine was designed, by any very great amount. As yet there are no improvements in gearing which will enable the armature to run at the same speed continuously under all loads, whether the car is at full speed or not. If some method of gearing could be devised which would permit of this, it would be of immense value, as it would obviate to some extent the great draughts of current which a motor demands when starting its load, as the counter E. M. F. would be always maintained by virtue of the rotation of the armature.

Mr. George Westinghouse, Jr., is said to have patented a device of this nature, using an oil bath in connection with it, but no details have as yet been published.

This inefficiency at the instant of starting and for a few moments after is one of the greatest obstacles in the path of the electric locomotive, when operated at a constant potential. A constant current system would, of course, obviate this matter of excessive current to some extent, but whether it would perform the work of starting a train with any greater total efficiency, is a question that I have not seen discussed. As to controlling the speed of the train, Mr. Sprague has proved beyond question that this can be done by varying the field strength in inverse ratio to the speed. By the use of a shunt-wound motor, the field current is perfectly independent of the armature current, and the field can be easily controlled by a rheostat. This also permits the introduction of electrical braking, as mentioned before. In a system of this kind, the advantages of having a part of the power returned cannot be overestimated. Series machines are usually used for railway work, because of their great initial effort, which is really an automatic effect. But when used on a constant potential system such as we are considering, the principle of electric braking does not apply, as regards returning energy to the line, though by reversing either the armature or field current, it can be stopped and reversed very quickly. The shunt method for the present case is preferable, however, for it admits of much closer regulation and adjustment than the other, and also is a source of economy, when stopping the train. As mentioned previously, a portion of the energy of stopping can be used for heating the train.

Besides the saving in weight of a train of given carrying capacity, and consequent increase of the life of the structure and of facility in handling the train, there also arises the question of economy of operation. But before considering this question in detail, let us consider the matter of generation of power.

The operation of a central station can, if it is properly constructed, be made very economical. The power should be well subdivided, both for the sake of flexibility and efficiency under all conditions of load, and also for immunity from accident. The high speed engine is now being compounded with excellent results, and is developing gradually into the triple expansion. The opinion of an excellent authority, Mr. C. J. Field, is that the best arrangement for a plant of such size as will be here needed would consist in using triple expansion high speed engines of five hundred horse power each, belted direct to multipolar dynamos. These, for railway work, would need to be compound wound. If ground were valuable, as is usually the case in cities, the boilers and engines would be placed in the basement, and the dynamos on the floor above.

As regards boilers, the Babcock & Wilcox water tube boiler has probably no superior for work requiring, as this would, the use of high pressure with minimum floor space. Its immunity from accident is also a great consideration. To be sure, they may cost more than the ordinary return tubular boiler, but their greater safety, equal economy and less space will go a long way toward their adoption. Their universal use in large plants in cities is sufficient testimony to their value for this sort of duty.

The engines, if economy of floor space requires it, may be built after the vertical or marine pattern. This will, of course, require more head room than would otherwise be needed, particularly if the "four cylinder triple" be used, having two pairs of cylinders in tandem, the low pressure cylinder being divided. The addition of condensers increases the efficiency of the system, provided there is plenty of water, and the air pump does not waste too much steam. Independent condensers, so called, are the best for all such work, and are very widely used. The exhaust steam from the air pump may be used in a variety of ways. Often it is used to heat the feed water, which the exhaust of the main engine is not usually applied to when condensing. A novel method, told the writer by Mr. Walter C. Kerr, of New York, was to turn the exhaust of the feed and air pumps into the receiver or low pressure steam chest of a compound engine.

Feed water heaters are used either in the way just mentioned or sometimes between the engine and condenser. They are of great assistance, both in economy of fuel and in preservation of boilers. In the present case, they would probably be run with the air pump exhaust. They are often able to heat the water to considerably over 100° Fahrenheit. Dynamos, of the size that would be necessary for the work in hand, are usually very efficient, 85 to 90 per cent. being a common figure. They should be belted directly to the engines, and, particularly when operating a three-wire system, it is preferable to have two machines belted directly to one engine. A 500 horse power engine would therefore drive two dynamos of 250 horse power each. Direct belting avoids the use of countershafting, which is always a source of inefficiency, expense and danger. The engines of the type under consideration would run at about 150 revolutions per minute. In order to have a convenient velocity ratio, and at the same time get the required peripheral velocity of armature, the dynamos would be multipolar. For the high potential at which it would be necessary to work, 660 volts at the station, the Gramme ring type of armature would be preferable, chiefly on account of the better insulation obtainable. This is the principal reason for the adoption of this type by the Thomson-Houston Company, in building the large dynamos for the West End Railway Company's great power station, in Boston. They also say that it offers certain mechanical advantages.

These dynamos would all feed into three "bus bars," as in any three-wire incandescent plant. The positive and negative bus bars would be connected to the two copper conductors on the line, while the neutral bar would be connected with the ground.

Having outlined the plant, the economy of the entire system can now be considered. The locomotives of the Manhattan Railway burn about six pounds of good anthracite coal per horse power per hour, and about 16 per cent. of its total cost, at the engine, goes for haulage and handling.

If the central power station be located by a railroad, or by the water side, the cost of handling is reduced to a minimum. And by using bituminous coal, costing not over $3 per ton, we effect another great saving; for this, when burned under good stationary boilers, will give an evaporation of not less than eight and one-half pounds of water per pound of coal. The triple expansion condensing engines, such as have been considered, will develop a horse power on 17 pounds of water per hour. Hence their coal consumption is two pounds of coal per one horse power per hour, which all will agree is a very reasonable estimate, when the progress of the past few years, in economical engine duty, is considered.

In Chicago, anthracite costs about $5 per ton, and bituminous coal about $3. If the assumption be made that a locomotive in Chicago will have to develop the same average power as on the Manhattan Railway, which is about 70·3 horse power, and if it be also assumed that the efficiency of an electrical system from engine to car axle be 55 per cent., 70·3 horse power would require the expenditure of 127 horse power at the power station; and there would be required six times 70·3 or 421·8 pounds anthracite coal per hour, costing $1.05, while with an electrical system there would be consumed, for the same amount of power developed, twice 127 or 254 pounds of soft coal per hour, costing 38 cents. These estimates do not include the cost of handling the coal, on the one side, nor the cost of condensing water, etc., on the other. They may be considered very liberal, but the duty is similar to what is being done every day by the best engines. The electric efficiency has been taken as rather low.

With the large dynamos that would be used, the efficiency of the first conversion should be 90 per cent. The line efficiency should also be 90 per cent., giving 81 per cent. at the motor terminals. This, if we take the whole at 55 per cent., will allow 68 per cent. efficiency for the motors, which is rather low when their large capacity is considered.

From what precedes, it can be seen that an electrical railroad would certainly be more economical in consumption of fuel than a steam system, both developing the same horse power, or working at the same rate. But with an electrical system, such as has been here outlined, the motor car is made to carry passengers, and thus an electrical train will carry more passengers than a steam train of the same weight. And by the use of lighter trains, greater ease in handling is obtained, and the absence of the heavy locomotive greatly diminishes the wear and tear of the road bed. Still further economy is effected by electrical braking, which, according to Mr. Sprague, would diminish the cost of the power plant by about forty per cent. Add to these commercial aspects the fact that if electricity were substituted for steam, the citizens living along the route or making use of the streets traversed by an elevated system would not be subjected to the continual nuisances of smoke, gas, oil, water, ashes, etc., which they would otherwise have to endure, and damages to property owners would be enormously diminished. If originally built for electrical operation, the elevated structure could be much more lightly constructed than is possible with steam trains.

The conditions prevailing on an elevated road are, in general, infinitely more favorable to electrical operation than those on an ordinary surface railroad, in the street below, and can be mastered with much less difficulty. Mud and dust will be unknown quantities; moisture and snow will be of comparatively little consequence; there is no interference from any other traffic, and in short, everything is in favor of the adoption of electrical motive power.

The chief objections offered by the Manhattan Railway officials are that in the experiments hitherto made the electrical locomotives could not get up speed in the required distance with a load as heavy as that hauled by a steam locomotive; and that the electric locomotive, as far as developed at present, is exceedingly inefficient, particularly at the start.

It seems to the writer that the first objection might be overcome if care were taken in providing a sufficiently heavy motor, and putting power enough in it to start up a train as quickly as is done by steam. In view of what has been accomplished in street railway work, it does not seem such an impossible problem to solve, if it be attacked in the right way, as to distribution of weight and supply of power.

As to the second objection, the fact seems to be lost sight of that a steam locomotive, when starting a train and taking steam the whole length of the stroke, is also a very inefficient motor. On the Manhattan Railway a locomotive is running twenty hours and is using steam six hours. But during the fourteen hours when steam is shut off from the cylinder, the boiler pressure has to be maintained at 130 pounds per square inch, and a roaring hot fire must be kept up.

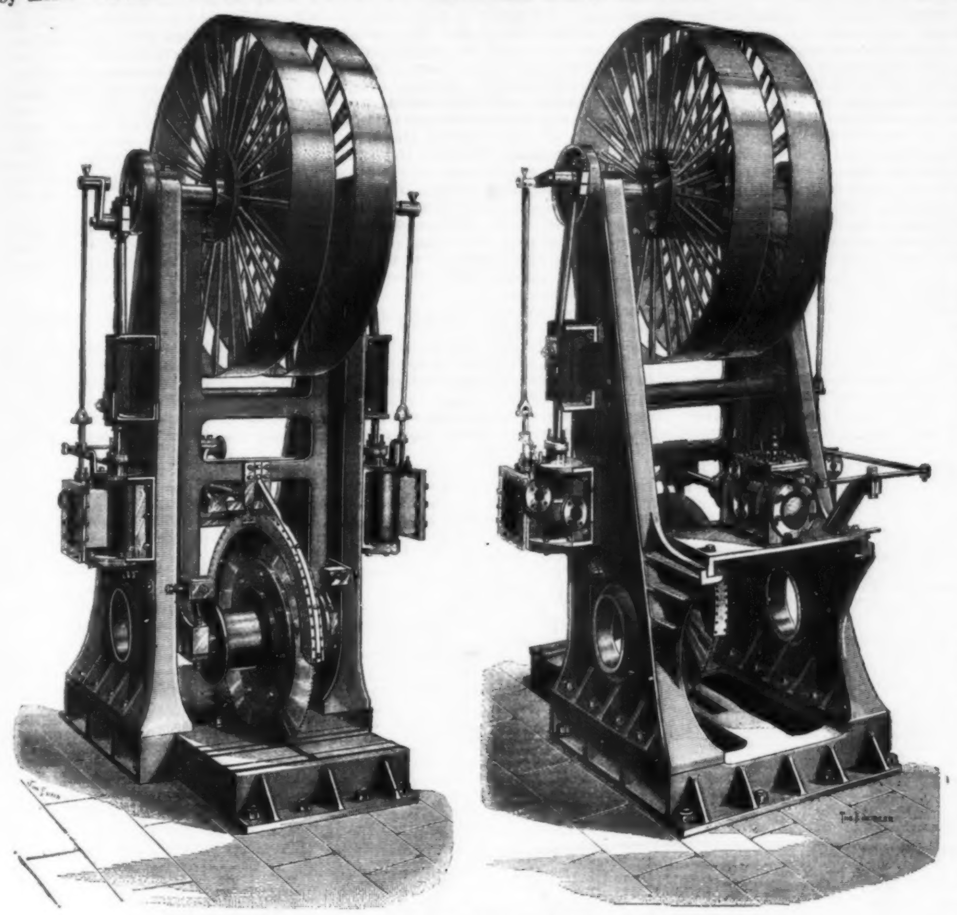
Whatever the working efficiency of the two may be, the cost in dollars and cents of electrical motive power, with trains of equal weights, can be reduced to a little over a third of the present cost of steam power, or even less, as was shown by the figures. However important the matter of speed may be, the second objection, as to lack of efficiency, does not hold at all, and still less when the dollars and cents are reckoned up. Considering all the advantages that would accrue, both to the railway companies and their patrons, it is small wonder that all look to electricity as the solution of the municipal rapid transit problem. Not many have undertaken the task as yet, but it is the writer's opinion that a little more concerted effort on the part of electrical engineers would be of very great help in hastening the substitution of electricity on the elevated roads.

(*To be continued.*)

It has been estimated from a microscopic examination of the word "hello," on a phonograph cylinder, that it contains 16,000 indentations.

OSCILLATING HOT SAW.

THE accompanying engravings illustrate one of four saws recently presented in *The Engineer* and supplied to the Mannesmann Tube Company, London, by Messrs. Thwaites Bros. The saws are 5 ft. diameter, and are combined with vertical double engines. These machines are used in sawing hot ingots 10 in. square.



IMPROVED OSCILLATING HOT INGOT SAW.

The cylinders are 10 in. in diameter by 16 in. stroke, and the engines run at 250 revolutions per minute, the saws running at 1,500 revolutions per minute. The center of the saw has an automatic traverse of 20 in., movement being given by a horizontal steam cylinder 9 in. diameter, which is fixed at the back of the saw and connected to the oscillating arms by a rod. Each oscillating arm is provided with a steel slipper, which slides in adjustable wrought iron guides. These guides are bent at right angles at the ends to form a stop for the oscillating arms, a piece of hard wood being fastened by a bolt to the inside ends of the wrought iron guides to act as a buffer when the saw has cut through the ingot. A hand lever is provided in a convenient position at the side for working the cylinder for oscillating the saw. The vertical cylinders for working the saw are securely fastened to the side of the standards by turned or fitted bolts, the crosshead working in cast iron guides, which are also securely fastened by means of turned and fitted bolts. It will be seen that the saw disk plate and flanged pulleys are cast in one piece. The saw disk plate on one side is turned down square for the saw to be fastened against it, the saw being inserted between the saw disk and a large mild steel washer plate. These are all bolted together by eight turned and fitted bolts 1¼ in. diameter. At the bottom end of the oscillating arms journals are provided, 3 in. diameter and 7 in. long, for the mild steel saw spindle, and are arranged with the journal caps underneath, so that the pressure is taken off the bolts. The other end swings on a trunnion pin of liberal diameter. The standards are made of cast iron, extra strong, of a good section, the top having a recess for the crank shaft journal brasses 4½ in. diameter by 8 in. long. Each standard has a good wide and long base, and is held to the base plate by ten bolts 1¼ in. diameter. The standards are bound together by a strong cast iron tie piece. The standards are mounted on a cast iron bed plate, in which provision is made for an arrangement for holding the ingots.

In the body of the bed is a water trough, in which the saw is partly immersed. This trough has holes for inlet and outlet pipes. The top half of the saw is provided with a neat wrought iron guard. On the crank shaft are keyed two extra strong wrought iron double armed pulleys, 8 ft. diameter and 1 ft. wide. The diameter of the flange pulleys on the saw disk plate is 16 in. and 1 ft. between the flanges. These pulleys are slightly rounded on the face.

WIRE ROPEWAYS, WITH NOTES ON THE PLOMOSAS LINE.*

By B. McINTIRE.

THE system of transporting material by means of the "wire ropeway," or endless traveling wire rope, has been thoroughly tested during the past eighteen years; the results proving that a well constructed ropeway, with the latest improvements, is as sure in its operation as is a railway. It has proved to be cheap in first cost and construction, reliable in operation (not being affected by changes in weather), and most economical in operating expenses and repairs.

Ropeways have been used for transporting many kinds of material, such as ore, cord wood, rails, lumber, sugar cane, produce, etc.

As is well known, there are on the Pacific coast many valuable mining properties undeveloped on account of the ore being of too low grade to be worked profitably by the usual method of erecting steam power reduction works at the mines. By grinding these ores in a mill driven by water power, which in many cases may be found within a few miles distance, these may often become valuable properties. The question of transportation is in many cases the only difficulty, and a well constructed wire ropeway will often be found to solve the problem.

The construction is the following: An endless wire rope, at intervals of from 140 to 2,000 feet, is supported on suitable sheaves, which are mounted vertically on the ends of cross arms fixed to the necessary posts or supporting structures, and at a sufficient height to clear all surface obstructions. At both ends of the line the wire rope passes around sheaves set horizontally. These sheaves are either grip or plane sheaves, as the case may require. Grip sheaves are used where power is to be supplied to the rope, or to prevent slipping where brakes are used to regulate the speed, the brake wheel being then attached to the upper side of the grip pulley.

Buckets or carriers of various designs, differing according to the character of the material to be handled, are used. These are suspended by hangers and clips, which are either inserted into the rope or strapped around the outside of it, and are attached at intervals determined by the amount of material to be delivered, calculating the rope to run at a speed of about 200 feet per minute. The clips are so made that they may pass over the rims of the carrying sheaves and around the horizontal terminal sheaves. The carriers may be loaded at any part of the road, either by the use of an automatic loader or by hand labor, while at the point of discharge the carriers unload automatically, the rope not being stopped either to load or unload.

When the point of delivery is lower than the loading point, and the inclination greater than about one in seven, the ropeway will run by gravitation, the speed being regulated by a brake; when less than one in seven, auxiliary power must be employed. A ropeway running 200 feet per minute, with ore buckets attached at intervals of 48 feet, carrying 160 lb. per bucket, will deliver 20 tons per hour. If run by gravity, with a loading device, and one man to look after it, one man at the brake and one man at the discharge end, three men can deliver 200 tons of ore, at a cost of about three cents per ton for labor. By using two clips close together on the rope, loads of 500 to 700 lb. per bucket or carrier can be transported.

In the year 1884 the author was called upon to construct and put in operation a ropeway for the Plomosas Mining Co., State of Sinaloa, Mexico. A record of the construction, together with a statement of the difficulties which had to be overcome, may not prove uninteresting from one familiar with this class of work, and may perhaps be valuable to other engineers who may have occasion to plan a similar plant. Before entering upon this work I had constructed a ropeway 4,400 feet long, for Mr. E. Wertherman, at Topia, State of Durango, it being the first ropeway built in Mexico. The Plomosas ropeway was the first to be constructed in what may be called rough country, with a so limited number of available points for sustaining structures and such enormously long spans. The profile, Fig. 1, shows the spans, which (starting with the lower terminal) are respectively 935, 863, 104, 1,378, 977, 1,935, 410, 1,066, 771, 833 and 433 feet; in all 9,705 feet. To this length was subsequently added 410 feet between structures 8 and 9, when the vertical turn sheaves were replaced with horizontal turn sheaves, making a total length of 10,115 feet, with a difference in elevation of 3,575 feet between terminals.

As a general rule, hewn timbers have to be used in ropeway construction, as sawed lumber is not available. In some cases, round poles are used. These, however, should not be employed, as they make a very poor structure, and are a continuous source of trouble and expense, taking twice as long to frame as hewn timbers, though employers are apt to think that there is economy in using the cheapest lumber that can be found, not considering the labor and subsequent expense of keeping the line in order.

In framing the terminal structures, I took great care to have the work well done, having it well bolted, and using large cast iron washers on bolts.

In erecting the intermediate supporting structures,

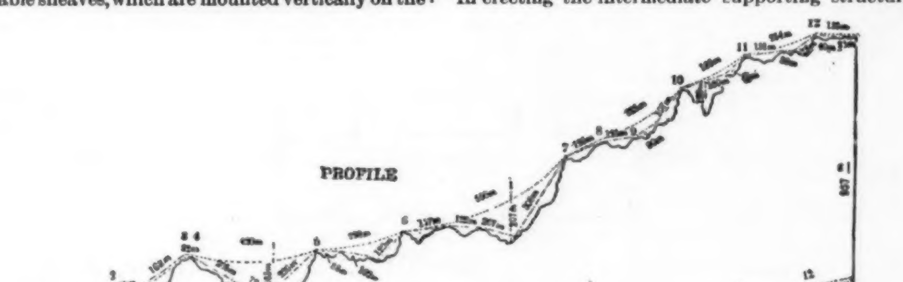


FIG. 1.—WIRE ROPEWAY—PLAN AND PROFILE OF THE PLOMOSAS LINE. (Measured in meters.)

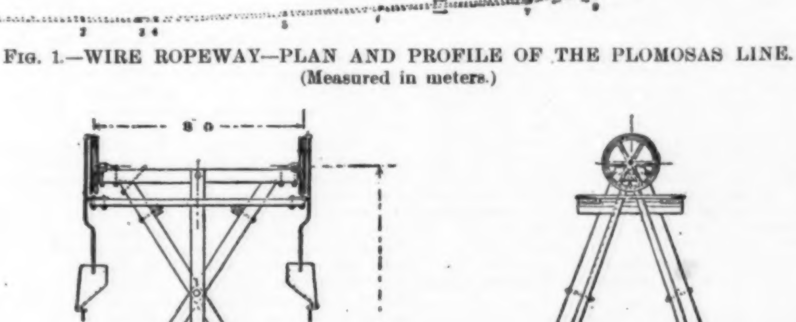


FIG. 2.—WIRE ROPEWAY—PLAN OF TRUSSED SUPPORTING STRUCTURES OR STATION FRAMES.

* Abstract of a paper read before the Technical Society of the Pacific Coast, July 9, 1890.—*Railway Review.*

use was at first made of such large trees as lay in the direct line of the ropeway, but it soon became apparent that such single post supports were of little use, although some of the trees were three feet in diameter. The vibration at these points was so great that a jerking motion was imparted to the rope whenever a clip passed over a sheave, and the latter began to cut out at the rate of ⅛ inch per week where the single posts were used, although these were braced in every conceivable way, some of them having as many as twelve guy ropes run out in all directions. The supports shown on the profile at the points marked 12, 11, 10, 8 and 7, were all originally of the single post type, but they were all afterward braced by having x-frames built around them, or were replaced by other structures, when the line was straightened out and the turn put in. The supports at 6, 5, 4, 3, and 2 were originally built as trussed structures, and gave good satisfaction from the beginning. Fig. 2 shows their construction, which is the best form for use in ropeways with great spans, being trussed in all directions and not being liable to get out of line, nor will the weighted side of the rope pull the cross arm out of level. All the bolts may become slack, and still the cross arm will remain horizontal, which is not the case in the four-post structure commonly used, and with which, after a few days running, the unloaded side of the cross arm will rise up, often showing a difference of eight inches in the level of the sheaves in the course of a week, and giving rise to the nuisance of keeping a man continually going over the line to tighten up bolts and get the cross arms back into place. In the truss structures, sills should always be used, as they prevent spreading, and keep the whole structure in line. During three and a half years, I did not have occasion to tighten a bolt on any of the Plomosas structures.

The Lower Terminal.—The lower terminal structure was made of 10 × 10 in. timbers, with 6 × 8 in. timber for the track (the length of which was 65 ft.), and supported on 22 in. round timbers for sleepers. The movable terminal should have a good rail on top of the carriage wheels to prevent its turning over should the front wheels be raised off the track, as would happen where the rope comes to a terminal at a steep angle from a station above it. It would not be necessary where the terminal is higher than the post before it, but in all cases it is a wise precaution to have a hold-down rail, as there have been cases where, in starting a ropeway, the terminal has turned over, doing serious damage to the machinery, buckets, clips, etc.

The transportation of material, when it has to be done on pack animals, becomes a very serious matter in certain classes of machinery. The rope for Plomosas was taken in ten pieces, each piece. of 2,250 ft. length, being carried on 7 mules, each carrying 321 ft. with a piece 10 ft. long between each pair of mules, making 70 mules to the train. It required three men to take care of each 7 mules.

At Plomosas, after the ropeway had been running four months, I had to replace two strands of the rope at points where short kinks had been made in transportation. These had been previously marked, as it was suspected they would give out, as proved to be the case.* The rope used at Plomosas was 13-16 in. diameter, plow steel of 30,000 pounds tensile strength per square inch, and was manufactured by the California Wire Works, of this city, from special material brought from Germany.

Repairing and Splicing.—After running the ropeway two years the splices commenced to give at the point where the two metal strands are tucked into the rope, to take the place of the hemp heart. I commenced repairing by splicing in new strands to take the place of those worn out. It may appear strange that the wear upon the rope at splices should have been so much greater than elsewhere. A flexible wire rope (19 wires to the strand) can, indeed, be spliced so that there will be little difference in the wear, but in a rope of 7 wire strands, made out of plow steel, at the points just above and below where the two steel strands are inserted into the core to take the place of the hemp heart, there is a space (about an inch in length) where the rope has 7 strands instead of 6 at the circumference. This makes the diameter greater and increases the wear at the splice. Another cause of inequality is that at this point, just below where the steel strands enter the core, there is a length of say one and one-half or two inches that has no heart at all. Sometimes an outside strand will crush into this cavity, exposing the other strands to undue wear. In a flexible rope the strands can be set together with a mallet, so that the splicing cannot be noticed.

The wire cables on ropeways need care, and, like all other elements of machinery, require proper lubrication, which they seldom receive. Tar is a preservant generally used. During a year and a half I used Swedish tar, or a tar that was sent me under that name. This was mixed with boiled linseed oil. I had the two boiled together and the mixture distributed on the rope in the usual way once a week. This was found an expensive and imperfect method, for the seats of the sheaves did not retain any of the tar after one day's run, and owing to the heat of the sun, I suppose, the tar hardened and baked on the rims of the sheaves, giving no protection whatever to either rope or sheaves.

I subsequently changed the mode of application by letting the tar continuously drop on the rope, about a drop falling each minute. This was a decided improvement over the first method of application, as the sheaves and rope retained a light coating of tar all the time, and the wear on the seats of the sheaves was reduced greatly after the continuous use of tar on the rope was commenced, while the sheaves ran four months before the tops of their rims had to be cut down, which previously had to be done every month at some points. Tar is, however, a very poor lubricant or preserver of rope that is operated under exposure to the sun, as the heat takes up what little lubricating properties it contains.

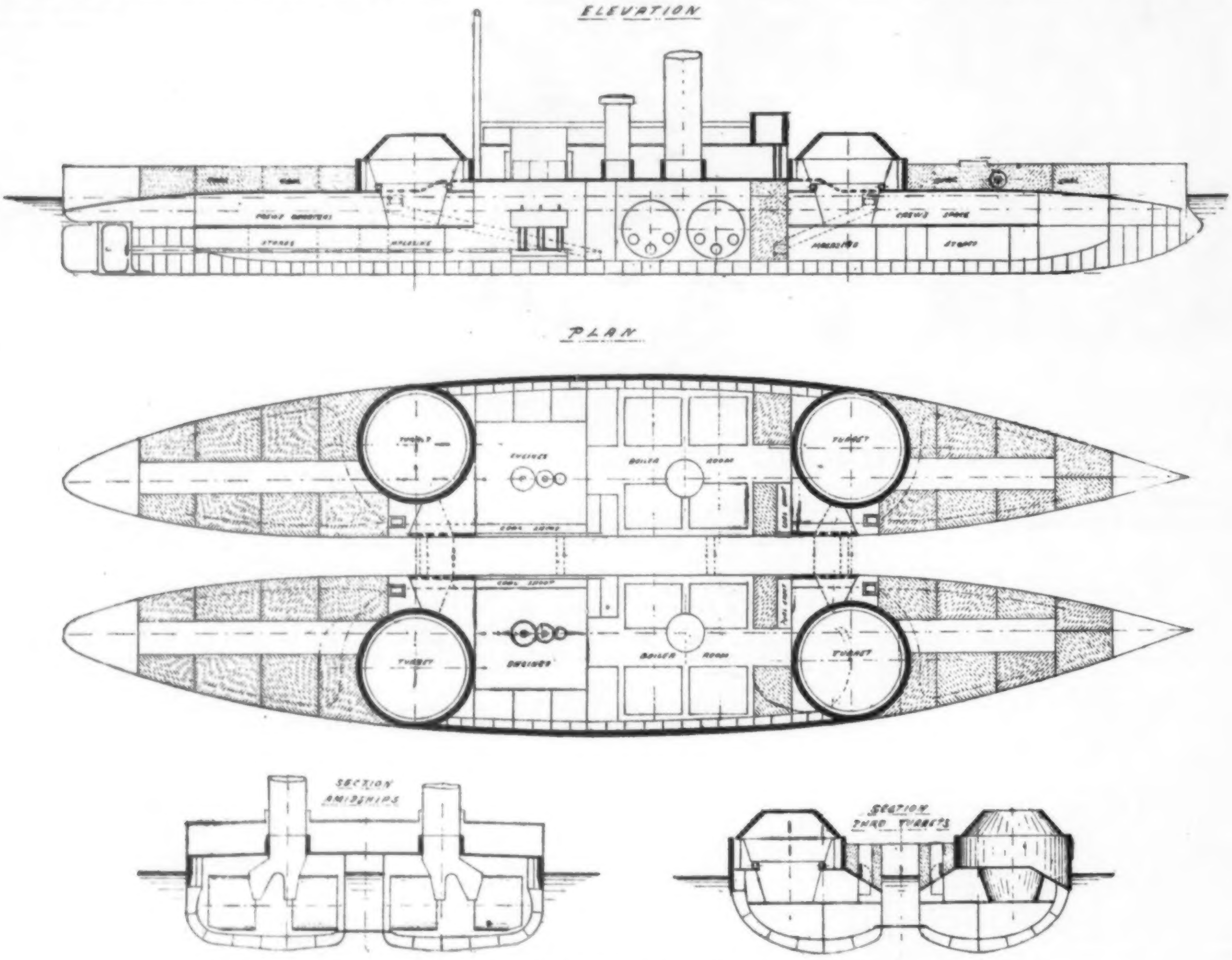
After running the ropeway a year and a half, I had occasion to replace a damaged strand, and found that the tar had not penetrated the rope. I also noticed a good deal of wear on the wire between the strands, caused by friction in bending when passing over the sheaves. I then tried black West Virginia oil, which was put on with an automatic lubricator, using three gallons per month. At the end of four months I examined the inside of the rope again, and found it thoroughly saturated with the oil, the sheaves also showing less wear. My expectation that the oil would preserve the manila core of the rope proved correct, for in renewing the splices, after using the oil six months, I found the hemp softer and more disposed to come out readily, without breaking up as much as before. The oil seemed to prevent the burning up of the core, which would in itself be a recommendation for its use; for a rope in which the core is destroyed is of little further use, as it will wear out very rapidly, on account of the unevenness of the strands. Whether due to the oil or not, the rope did not show much wear during the last two years. There was also quite a difference in the wear of the carrying sheaves, as they lasted six or seven months without the tops of the rims having to be cut off, and there was less wear on the grips on the terminal sheave.

The cost of the construction of the Plomosas ropeway was $19,400, and the total saving by its use for the first year was $52,979.50, or a clear saving to the company (after paying for the ropeway) of $33,579.50.

*If a short kink occurs it may be very successfully removed by fastening two clamps to the rope, one on either side of the kink, with just room between to use a mallet freely. Then by unbending the kink in the direction in which it was formed, at the same time twisting the rope with the clamps into proper shape, and setting down with a mallet, the worst kink can be taken out so that it cannot be noticed. Trying to pull or hammer out a kink will only make it worse, and weaken the rope more than if it were left in.

PURDY'S ARMORED TWIN WAR VESSEL.

In form the hulls have their outer sides on exactly the same lines as ordinary ships, but their inner and adjacent sides for the main length of midship body are made vertical and parallel, separated at a convenient distance from each other. Forward and aft of this, lines run in fair and easy curves to the ends. As low down as possible, where the turn of bilge will allow, strong steel struts are fitted at intervals connecting the two hulls together, their palms being well secured to the double bottom inside, forming very efficient braces to maintain the rigidity of the vessel. Above, the decks are continuous over both hulls, and with the struts below form a complete couple, binding the whole structure together.



IMPROVED ARMORED TWIN WAR SHIP.

This form of hull is a compromise between the forms of twin hull previously built, viz., of the divided hull, as in the Castalia, and of the complete double symmetrical hull, as in the Calais Douvres, neither of which vessels had any connection between the hulls below the water line. Another object of the parallel riders in the design is to prevent the too great augmentation of wave between the hulls.

It will be seen that this type of vessel is adaptable to all classes of ocean-going vessels.

In its application to war vessels, the design shown in the engraving represents the general arrangement of a battle ship of light draught suitable for coast and harbor defense, the principal features and advantages of which are as follows:

1st. Practically two complete fighting ships with their full complement of guns and men, each forming a re-enforcement and protection to the other, and carrying a belt of side armor nearly double in thickness that of any other vessel of equal displacement.

2d. The arrangement of spaces internally gives an exposed side of the hull proper less than is obtained in the monitors, combined with a moderately high freeboard, giving her good sea-going qualities.

3d. Very great stability, forming a steady platform for the firing of guns, and consequently much greater accuracy of aim.

4th. Turret armor, side armor, and protective deck

armor, are all combined and merge into each other in a very neat and compact manner, forming complete protection throughout.

5th. The protective decks forward and abaft of the turrets are intact without the usual number of hatchways and openings cut through them, and give complete protection, the only openings required being one in each for a coal chute, placed behind the turrets and fitted with water-tight covers.

6th. The ends of the vessel above the protective deck are built up to the required height, and intended only as a superstructure to give the ship freeboard, to insure her good sea-going qualities. This superstructure being used only as coal bunkers, where the coal will afford the most protection, and being above the water line, may be seriously damaged or nearly all shot away during action without materially affecting the safety of the ship.

7th. In steering and maneuvering qualities she will be superior to a single hull ship, having the centers of machinery much further apart.

8th. In case of accident, disablement of machinery, or filling of one of the hulls, the other would be able to work independently and have sufficient buoyancy to float her.

9th. In speed, as each hull has its own separate engine power, the speed may be as great as that of any other vessel of equal displacement and horse power. As this design combines the sea-going qualities of cruisers with the low exposed side (of the hull proper) of monitors, it may be designated a "cruising monitor."

In the application of this form of twin hull to passenger ships and other vessels, some very important advantages are obtained, among which are included greater comfort, safety and accommodation. First, the great *bete noir* of ocean travel—sea sickness—will be considerably modified. Magnificent cabin accommodations can be obtained owing to the enlarged deck room over the two hulls. Greater safety is assured against loss by collision with icebergs or other vessels, as it would be impossible for both hulls to be damaged at the same time; also in case of break-down or accident to the machinery, the whole ship would not become disabled.

Regarding the docking of a vessel of such great beam as this, although there are no graving docks capable of receiving her, slipways are now in existence on which she could be taken up easily.

The foregoing particulars are from the *Inventive Age*. Mr. A. J. Purdy, of Washington, D. C., writes us as follows:

For each hull, separate, the dimensions are as follows:

Length of vessel between perpendiculars	280 ft.
Breadth, moulded	39 ft.
Depth, moulded	19 ft. 6 in.
Draught of water	16 ft. 6 in.
Displacement (each hull)	3,500 tons.
Coal supply, but bunkers not filled	600 tons.

She will have one set of triple expansion upright engines in each hull of 3,000 indicated horse power, which it is estimated will propel her at a speed of 14 knots per hour, with an endurance of 10 days' steaming without recoaling.

Her armament will consist of eight 10 in. R. B. L. guns, each having a range of 208 deg.; 4 rapid fire machine guns mounted in the fighting tops on the mast heads, and 6 rapid fire guns mounted on the hammock berthing on deck, as protection against torpedo boat attacks. This will constitute the whole of her armament for coast and harbor defense, and will form one of, if not the most, formidable battery afloat.

The side armor will be 20 in. thick, turret 12 in., and protective decks 3 in. and 2 in. respectively; the main walls of the turrets being stationary, only the sloped canopy revolving.

The cabin and officers' quarters are arranged on the main deck amidships, from which easy access can be attained to either end of the vessel. Seamen's quarters, mess rooms, etc., are all below the protective deck at the ends, and afford large and commodious accommodations.

A special feature is added in connection with the coal supply, in the form of an inclined coal chute, which will convey the coals direct from the bunkers down to the fire rooms without any trimming being required. The dotted lines shown on the tracing running through the bunkers represent an overhead trolley way along which the coals are led in an iron tray to the coal chute door.

With regard to the principle involved in the design, namely, the twin hull form, I may say that that alone would have been quite insufficient to have encouraged me to get out a design on that plan for a war vessel, but the idea of combining the monitor type with a sea-going cruiser, and retaining all their strong points, urged me on to the work, and I think the result has turned out perfectly satisfactory.

In the design I have fixed the freeboard at 6 feet, being exactly double that of the monitors, which, together with the bridge houses amidships, renders her a reliable and seaworthy vessel.

But the great question, about which criticism will be expressed, and the one which I think is the most important, is in the strength of the connections between the hulls. If the connections can be made strong enough (and it is generally allowed that they can be made any strength required), then all other questions are secondary. Regarding what the strength of the strut connections should be, I consider it this way: We may suppose that at the worst the entire strain will never exceed the total weight of one of the hulls, and that would then be distributed among all the struts, and naturally in a lateral direction, giving direct tensile strain upon the struts, and the struts as arranged are each of them capable of standing something like the whole weight of one of the hulls before breaking. Therefore, I think there need be no fear on that part of the design.

Another question is as to the effect of heavy seas breaking over the front of the bridge houses; that I consider will be no worse than is now experienced by single hull ships, and they have to be made strong enough to stand it.

For passenger ships the advantages of the twin hull principle are so many and so obvious that they should not be ignored without very exhaustive trials, and I think it will become a matter of necessity before long. Hoping, sir, that you will be able to appreciate my humble endeavors in trying to improve on old Noah's ark (after our thousands of years of engineering progress), which still holds the day.

A MULTIPLE PORTRAIT.

WE have received from one of our readers, Mr. G. Paboudjian, of Constantinople, a curious photograph, which we reproduce herewith, and which was taken by a process which is very simple, though not comprehensible at first. We see the same subject represented a number of times, and the whole presents the aspect of a number of persons standing in a line. In order to obtain such a photograph, Mr. Paboudjian uses two mirrors, A and B, placed parallel and separated by an interval of about twenty-four inches. In this space, at C, he places the subject to be photographed. Every one knows the effect produced under such circumstances, from having often observed it. In cafés, the shops of hair dressers, and in our own apartments even, there are often two mirrors that face each other, and in which we may daily observe the curious effect of perspective in question. It is this effect that it is a question of fixing upon the photographic plate, but without the operator himself appearing thereon with his apparatus. For this, as shown in the diagram, it suffices that one of the mirrors shall be a little taller than the other and that the apparatus, placed above the shorter one, shall be slightly inclined toward the

FIG. 1.—REPRODUCTION OF A PHOTOGRAPH OF A MULTIPLE PORTRAIT.

floor. It is necessary, too, to use mirrors without frames, since the latter, on being reflected in the glass, would produce a very bad effect. The experiment may be complicated by employing three mirrors arranged in the form of a prism, the reflecting surface being turned inward. Two or three persons placed in the interior give the impression of a large crowd. In order to obtain a photograph of this kind, it is clear that it is necessary to pose. The light is always inadequate for making an instantaneous photograph, especially if it is desired to have the distances (which are less and less illuminated) as remote as possible. As for employing magnesium, that appears to be difficult, since, on account of the reflection upon the mirrors, there would be a danger of cloudiness. It would be curious, especially in the three-mirror arrangement, if two persons could be

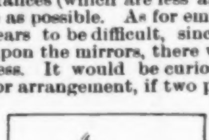


FIG. 2.—DIAGRAM SHOWING THE ARRANGEMENT OF THE APPARATUS.

taken in motion—say leaping or dancing. There is here quite a simple means of always having a large number of models at one's disposal.—*La Nature.*

[Continued from SUPPLEMENT, No. 774, page 12368.]

STEREOTYPING.*

By THOMAS BOLAS, F.C.S., F.I.C.

III.

PLASTER PROCESS, ELECTROTYPES, CASTS IN STEEL, IRON, BRASS, AND OTHER REFRACTORY METALS, CELLULOID, RUBBER, AND GELATINOUS COMPOSITION, AUTO-STEREOTYPING, MISCELLANEOUS PROCESSES.

IT is useless for me to attempt giving anything like such full working details of the numerous processes which have to be considered in this lecture as was the case when I spoke of the paper mould process, as each would probably occupy as much time as was taken up recently with the paper process alone, and, even by trespassing on your patience as much as was then the case, some ten or fifteen lectures would be needed.

The invention of the plaster mould process was spoken of in the first lecture, and in spite of the comparative slowness with which work is turned out, and the cumbrous nature of the appliances required, the plaster process survives, principally for casting from formes of music type. In this case it is specially adapted for the work, as so many of the music characters hang over the body or shank of the type, and these overhanging sorts would be very liable to injury in moulding by the paper process, also in the drying press; while the plaster mould has the advantage that imperfect joints in the lines of the music staff can be made good by carefully drawing a piece of metal rule along the lines in the mould.

When a forme is set with the view of being stereotyped by the plaster process, quadrats and spaces as high as the shanks of the letters are often used, and, for the convenience of stereotyping, music fonts are ordinarily furnished with high spaces and quadrats.

Narrow clumps are generally placed so as only just to surround the forme, and outside these we have the ordinary low furniture. The first thing is to rub a paste of plaster of Paris and water well into the interstices of the forme, this being done with the hand, and as the plaster sets, the excess is brushed away with a stiffish brush, so as to leave the face of the type clear of plaster, the depths of the forme partly filled in, and the vertical sides of these depths sloped off with banks of plaster.

It is desirable to allow this "filling in" to become dry before further treatment, and warmth may be employed to expedite the drying, after which the face of the type is finally cleaned by the brush, and any fragments of plaster which clog the faces of the letters must be picked out. The forme, being now clean and dry, is thoroughly oiled, enough oil being used to saturate the surface of the filling in plaster, and although the type should be well oiled, the hollows on the face of such letters as *o* or *e* should not be left full of oil. The low priced thin mineral lubricating oil recommended in the case of the paper process is inconveniently thin, so it is better to use such an oil as cotton seed oil or rape seed (colza) oil.

Some strips of thin sheet metal are now laid on the furniture, outside the narrow clumps,* and an iron frame about three-quarters of an inch deep is laid over, so as to inclose the forme with its clumps, when some plaster of Paris, mixed with water to the consistency of thick cream, is poured over the type, after which a brush is worked with an up and down motion in the plaster covering, so as to chase away air bubbles, but this brush should not be drawn out of the plaster till the dabbing is finished, or fresh bubbles would be created. The frame is now filled with the mixed plaster, and as it begins to set, the top is scraped off level with a straight edge. All the plaster should be of the same mixing, as, if a stiffer plaster is used to fill up, there will probably be distortion in drying. Rather low priced plaster is often to be preferred for this purpose than the very finest quality, which commands its high price mainly on account of its whiteness, freedom from dark specks, and the fineness with which it is ground. It is of the utmost importance that the plaster used should have been freshly roasted, and at such a heat as to set quickly and firmly. The stereotyper can easily judge of these points for himself. Extremely fine grinding is of no advantage, as the surface obtained is no better than with moderately fine grinding, while flatter and better casts are obtained in the latter case. As a rule, the plaster should be obtained direct from the maker, who will usually supply the smallest quantities if sent for; and generally the grade sold in London as "fine" is more suitable than "superfine" or "double superfine." In mixing the plaster, a quantity of water is taken in a basin, and powdered plaster is added in a stream till it is judged that enough has been added. Before proceeding to mix with a spoon, it is well to see that the water has penetrated to the top of the blunt cone of the plaster, which at this stage will stand above the water level. In this case it is easy to mix the plaster without forming many air bubbles, which would not be the case if the water were added to the plaster. Mixing basin, brush, and spoon should be well washed immediately after use.

In ten minutes or a quarter of an hour the plaster mould should be set, and the cast can be removed, and for this purpose a tool like a miniature two-pronged crowbar is used, the opposite sides of the frame being gently prized up in succession to the minutest appreciable extent, after which the frame, with its cast, can be lifted off, but any unwatchful application of force in this case will spoil the mould. The moulding frame is always beveled, so that the plaster cast can readily be removed from the top, and the cast is now baked at a heat of from 200° to 210° Centigrade for about two hours, care being taken to so place it in the oven that the air can circulate as freely all round it as practicable; for example, on its side, or, better still, on a flat shelf formed of such heavy wire netting as was previously referred to (Lecture II.)

Here is a mould already baked, and the essential point in casting from such a mould as this is to retain the melted metal in contact with it for a considerable time, say ten or twelve minutes, but it is quite easy to obtain a cast without the heavy and expensive plant ordinarily used. Over this gas burner is a rectangular iron dish, and it is now heated to about the melting point of type metal. In it I place the plaster mould face downward, the border of the mould having been cut away at two points so that the metal can flow freely under it; and over the mould is fixed a bent iron plate, which will prevent it rising nearer to the top of the dish than an inch, when metal is poured in. Having now filled the iron dish with melted type metal so that the plaster mould has floated up against the stop, I will leave the gas burning for about ten minutes, and if it is then extinguished, we shall have a good cast as soon as all is cold.

In actual practice, the rim of the plaster cast is cut away at two or three points, and it is placed face downward into an iron box, called a dipping pan (Fig. 24), while under it is a loosely fitting iron plate. The cover of the dipping pan is held in position by the iron strap and screw shown in the diagram, but this

* Lectures delivered before the Society of Arts, London, 1890. From the *Journal* of the Society.

* Clamps are not essential in working the plaster process, but are desirable for several reasons.

cover is cut away at the corners so that the metal can freely flow in. This dipping pan is lowered into a pot of melted type metal and kept there for ten or fifteen minutes, after which it is lifted out and cooled. The plaster casts floats up against the lid of the dipping pan, while the floating plate rests against the rim of the plaster mould, thus gauging the thickness of the cast.

Little need be said about the trimming and finishing of the cast except that, as the cast is not of an accurately gauged thickness, and, moreover, as the floating plate is rough—as there would obviously be no advantage in surfacing or planing it—it becomes essential

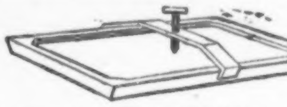


Fig. 24.—THE DIPPING PAN.

to trim or plane the back of the plate, and this is generally done by a special surfacing lathe. Although plaster expands at the moment of setting, it afterward contracts in drying, and a plaster stereotype is, therefore, smaller than the original by about 1-80th linear.

Gypsum, the mineral which, when gently roasted, gives plaster of Paris, may be regarded as a compound of sulphate of lime (calcium sulphate) and water in the proportions indicated by the formula:

$$Ca\,SO_4 \,.\, 2\,H_2O$$

The above formula corresponds to about 21 per cent. of water in the mineral, but when the gypsum is exposed to a heat ranging from 120° to 250° Centigrade, about three-fourths of the water represented by the above symbol is driven off, and the gypsum falls to a coarse powder, which then has approximately a composition expressed by the formula:

$$2CaSO_4 \,.\, H_2O$$

This expression corresponds to about 6 per cent. of water, and if the plaster in the course of manufacture is heated above 250° Centigrade, and the retained water is reduced much below 6 per cent., the plaster will harden but slowly. In hardening, the sulphate of lime reunites with water, forming a compound which is probably identical, from a chemical point of view, with the original gypsum.

When the mould is baked at a temperature of about 200° or 210° Centigrade, the greater part of the water is driven off, and the mould retains the 6 per cent. or so which is contained in ordinary plaster; but during the long contact with the fused type metal, at a temperature of about 320° or 330°, almost the whole of the remainder is driven off, and a sound cast is not obtained until this is the case. The reason why the thick plaster cast is not baked in the first place at a temperature above the melting point of the metal, and a cast obtained by simple pouring in of metal, is the extreme friability of the completely dehydrated mould. Messrs. Sharrow & Anderson, who work the plaster process in London and turn out about 200 music pages a day by this method, have been good enough to send me a set of specimens showing the various stages—the forme and moulding frame, rough cast and dipping pan, and also a finished plate.

A modification of the plaster process exists, in which the friability of the completely dehydrated plaster mould is overcome by the expedient of making the mould of extreme thinness, and in close contact with an iron plate. Indeed, the mould is so thin that the face of the cast is virtually made on the surface of the iron, the plaster in this case adhering to the iron in patches and ridges, forming reverses to the depths of the original.

A woodcut consisting of a close mass of fine lines, without large patches of white, or a grained phototint block in which there are no considerable depths, can be easily reproduced by a method of this kind, as the mould adherent to the iron plate consists of very small and thin deposits of plaster which have not much tendency to scale off, and which can be completely dehydrated by exposure for a short time—even a few minutes—to a heat about equal to that of melted type metal. Sometimes the iron plate is studded with small holes, tapering larger toward the back, so as to give a better hold to the plaster, but this device is especially needed when such an original as a forme of type is moulded from, and the reliefs of plaster are more considerable. A method of this kind may, in some cases, compete for rapidity with the paper process.

In working by this method, the original—after being "filled in" with plaster, if necessary, and oiled—is smeared over with a thin layer of mixed plaster, and the iron plate to be used (this may be one plate of the casting box used for the paper process) is similarly smeared over with plaster, but, naturally, the iron must not be oiled—indeed, it may be advantageously rubbed over with the white of egg to promote adhesion.

The two plastered surfaces being now pressed together with considerable force, ten or fifteen minutes are allowed for the plaster to set, after which all that excess of plaster which exudes from the sides is trimmed off, the mould on the iron plate is dried at about 320° Centigrade, and the cast is made by backing up the mould with another iron plate (or the other leaf of the casting box), and pouring in metal as when operating by the paper method. A modification of this mode of working can be used in making reproductions of medals by casting in plaster moulds, two plates of iron, the register between them being insured by steady pins, forming the framework of the mould, the mould being then made by spreading a little plaster on each iron surface, and compressing the original between them.

The original must not only be slightly oiled, but must be inserted in a hole cut of the right size in a sheet of oiled paper, otherwise the two parts of the mould would not separate.

The electrotyping process is very extensively employed in making stereotypes* of engravings, or of letter-press matter containing engravings, and when the original wood is to be moulded from the electrotype, this method is perhaps the most desirable process of stereotyping, as no moisture or heat is used in moulding; and in spite of what I said about the best possible stereotype by the paper method being equal to the best electrotype, the average commercial electrotype of the present day is very much better, as regards surface and definition, than the average commercial stereotype by the paper process.

If an electric current is passed through a solution of copper sulphate (bluestone or blue vitriol), so that the current passes from one copper plate immersed in the solution to another copper plate also immersed in the solution, one of these copper plates will become thicker from the deposition of copper, while the other plate becomes thinner by the dissolving away of just so much copper as was deposited upon the first. In this case, although the solution of sulphate of copper is doubtless decomposed and reformed during the action, it is there at the end, and for our present purpose we may regard the change as a mere transference of copper from one plate to the other, the deposition taking place on that copper plate connected with the zinc plate of the electric battery, and the dissolving away taking place in the case of that plate connected with the other pole of the battery, which may be a silver plate, a platinum plate, or a carbon plate. This action you can see going on before you, not only with a battery, but also with two forms of dynamo machine used as the source of the electric current, and if I replace one of those copper plates, upon which more metal is being deposited, by a wax mould of typographic matter well brushed over with black lead, the copper is deposited on this mould, and in time there will be a compact film of copper covering the mould.

This film when thickened up by a layer of type metal forms the ordinary electrotype used by the printer.

In the room is a very complete set of specimens illustrating the various stages of the ordinary process of electrotyping, these having been lent by Messrs. Richardson, Koolman, and Isger, and the shortness of time at my disposal must make me content with showing you these, rather than demonstrating every stage of the process. There are also some illustrations sent by Messrs. F. Plummer & Co.

The forme from which a stereotypic cast is to be made by the electrotype process should be surrounded with type-high clumps, and be filled in with plaster of Paris, as in the case of a forme for reproduction by the ordinary plaster method. Then the forme should be thoroughly brushed over with powdered black lead. All is now ready for moulding in a bed of wax. It is desirable to use genuine beeswax (unbleached) and to soften it by adding to it about one-seventh of the turpentine sold as Venice turpentine, and when these materials are melted, it is usual to stir in a little (say one thirtieth) of finely powdered plumbago (black lead).

The wax mixture having been melted in a jacketed steam pan or water bath, and well stirred, it is allowed to settle for a second or two, and a strip of paper is drawn along the surface to bring any air bubbles to one side, when the wax mixture is ladled out into shallow pans, about one third of an inch deep, and cast of soft type metal, called moulding pans (Fig. 25),

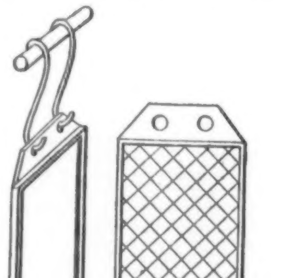


Fig. 25.—MOULDING PANS.

these being laid out on a level slab. It is well for the pans to be very slightly warm when filled, and they should be filled so that the wax stands well up to or a little over the edges. As a rule the wax does not crack in cooling unless it has been adulterated with the so-called Japan wax, but one remedy in this case is to add a little more of the turpentine. Unless there is gross clumsiness in filling the moulding pans, nothing more than a few isolated air bubbles will be formed, and these can be readily broken by touching with a pointed iron rod, which may well be warmed, so as not to chill the wax. The wax, when set, should, like the forme, be well black-leaded with finely powdered black lead, a soft, long-haired brush being used in its application. The moulding must not take place until the wax has thoroughly cooled, as, if this were done, the internal portion being softer, would very likely exude, but the wax plates, when once cooled, may advantageously be kept ready for use in a warm place rather than a very cold place.

For moulding from the type, a rather lightly built hydraulic press, made something like Fig. 26, is used, the only notable features besides lightness of build being the shortness of the rise, and a slab of iron on the bed, which can be pulled out drawer fashion. The forme being placed on the draw slab of the press in such a position that it shall come fairly over the ram, the blackleaded slab of wax is laid over it, and sufficient pressure is applied to mould all the details. In removing the mould from the forme, the same sort of care is required as when removing the plaster mould from the type, and when removed there will always be some superfluous wax to trim off. The parts of the mould corresponding to the more extended whites will probably require building up with wax, so that the electrotype shall have sufficient depth, and perhaps the simplest way of doing this is to hold a pointed pencil of iron or copper (building iron) in the right hand, and having warmed the metal rod, a slender stick of wax is held against it, so that a slow and steady stream of melted wax flows from its point. A watchful person can soon learn to lead this stream to the required places, and can raise the wax close to the borders of cavities in the mould, without fear of filling them. Several "building irons" of assorted sizes should be provided, and if a minute gas jet plays on the tool, a little way from the tip, time will be saved;

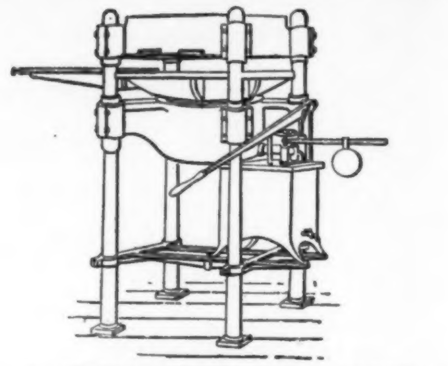


Fig. 26.—HYDRAULIC PRESS FOR MAKING THE WAX MOULD.

the gas being led through the hollow stem of the "iron" by an India rubber pipe about one-sixteenth of an inch in diameter. For "raising" the mould between fine lines, an ordinary pen may be mounted in this way, the small gas jet playing on its back, and dips can be taken, ink fashion, from a pot of melted wax. A building pen, capable of holding more wax, and suitable for coarser work, may be made out of a piece of copper wire cable, the wires being cut away at various points, so as to make a conical termination ending in two wires only, which form the working point, and the tool will be more lasting if each cut-off end is brazed down in its place with a minute patch of spelter or silver solder.

The wax must now be thoroughly blackleaded by beating and rubbing finely powdered black lead on to the face of the mould, either by hand or by a machine, until every part is covered, after which the back and sides of the moulding pan are painted over with melted wax to render the surface non-conducting, and all is ready for the depositing bath. Very much depends upon the nature of the black lead (plumbago, graphite) employed to make the surface of the mould conducting, and the electrotyper is often so much impressed by the desire to obtain a "perfectly pure" article, or something of the "very finest quality," that he pays quite extravagant prices to those who profess to supply such. Black lead, which is a form of the element carbon, is a mineral, and is always accompanied by traces of impurities, such as iron or earthy matters, and, although samples containing much earthy matter are less desirable than those containing a small proportion, the point at issue is mainly one of structure. Black lead ranges from hard crystalline scales to almost an amorphous mass, and neither one extreme nor the other is most suitable, but the kind best for our purpose is one which in grinding will break up into very minute and *thin* scales, a quality which can be recognized by a microscope examination, but a practical test is best for the electrotyper. A moulding pan having been filled with wax and cooled, a plate of thin sheet metal, having a slot about a quarter of an inch wide in it, is laid stencil fashion across from edge to edge, and is held firmly in position while one of the samples to be examined is brushed through the slot for a certain number of minutes. The stencil having been shifted, other samples, perhaps to the number of twenty or thirty, are similarly brushed on the slab of wax, after which it is put in the depositing bath and connected to the source of current, when the rapidity and perfection of the covering on the various strips will give nearly all the information wanted, although before finally deciding, the three or four samples which come out best should be tested on an actual mould having rather deep and narrow lines. In this case the quarter inch test strips would be no use, and a very good way is to cut out a metal or card templet, which will leave, say, a fourth of the mould uncovered for each sample. A suitable black lead is generally made worse by platinizing or gilding, and a black lead most suitable for a soft mould is not always the most suitable for a hard mould.

Not only have many other materials than wax been used in typographic electrotyping, but gutta percha is now very often used in France; also there are other ways of moulding. These matters I would much like to discuss at length, but time does not permit. I may, however, refer to Mr. Clay's convenient method of moulding, by which the "filling in" of the forme with plaster is avoided. A piece of stout linen is laid on the forme, and over this a sheet of India rubber, after which the moulding pan is placed in position and pressure applied; in this way a general impression is obtained, and a second impression without the linen and India rubber sheet gives a moulding of the sharp face of the forme. The essential point is to insure exact register in placing the mould in position the second time, a very easy matter if the chase and moulding pan are provided with corresponding pins and holes. By using a soft wax, a mould of moderate size can be made by this method with an ordinary printing press or a screw press.

In the depositing bath a simple solution of sulphate of copper, nearly saturated, is all that is wanted, and, although London electrotypers in many cases still use the Smee battery, a series-wound dynamo, driven by a steam engine, is, under ordinary circumstances, a much more economical source of electricity; but the special circumstance that favors the survival of the battery is the facility it offers for depositing during the night, when it would be an additional expense to

* Among the London craftsmen the words stereotype and electrotype, or rather "stereo" and "electro," are used as distinguishing terms, and the former term is so exclusively applied to the stereotype in type metal, that to speak of an electrotype cast as a "stereotype" is regarded as a barbarism.

keep the engine running; but even in this case secondary batteries charged by a dynamo during the day would probably be more economical.

Here is a small Siemens series-wound lighting dynamo (D 6), a kind of machine which would in many cases be better suited to the needs of an establishment for typographic electrotyping than are some of the specially made depositing machines, which are primarily intended for operations in which much heavier deposits are required, and this machine, while consuming only about a quarter of a horse power, and running quite slowly, will give a current of about twenty amperes with a tension of eight volts. It is now giving about that current, and is depositing copper over an area of something like two square feet, at the rate of about 184 grains on the square foot per hour, and you see it gives good deposit with this current of no less than 10 amperes to a square foot of surface. We might have six or eight depositing cells in series, each depositing the same amount, and giving a total deposition of from 2,000 to nearly 3,000 grains of copper per hour. In using one "series" machine by itself some precautions are necessary to prevent reversal, but when several machines are in use, one can be used to excite the field magnets of the others, an arrangement which conduces much to convenience of working, and is, moreover, suitable for the charging of secondary batteries.

When a sufficient thickness of copper (say 1-30th to 1-40th of an inch) has been deposited upon the wax mould, hot water is poured on the back of the copper electrotype (called the "shell") to disengage it from the wax mould, and the rough back of the shell is "tinned" with a coarse solder consisting of equal weights of tin and lead, such coarse solder having less tendency to run through any holes in the shell than would be the case with a solder having a full proportion of tin. This alloy is usually granulated by being poured through a gauze net into water, and it should be quickly dried, otherwise some oxidation will take place. The shell having been trimmed to the outside of the clump marks is laid face downward in a shallow iron pan (backing pan), which can be heated either by being supported on the surface of a bath of melted backing metal (generally made rather soft; lead 16 to 18 parts, antimony 1 part, a little tin—say three-fourths of a part—being added, unless the lead used is known to contain tin) or by a gas burner. If the shell tends to curl, it is easy to keep it tolerably flat by laying iron bars on the level edges left by the clumps, and the clean back of the shell is now brushed over with the acid chloride of zinc solution (see foot note p. 12367, Lecture II.), and sprinkled with the granulated solder, a final brush over with the solution being given if the solder does not spread to all parts immediately. The backing pan may now be removed from the source of heat, and, before the solder has time to set, melted backing metal is poured on in a steady stream, commencing in the middle and traveling outward as a spiral, so as to build up a thickness of at least a pica all over the shell,* the clump edges of which may be turned up so as to form a dish, unless iron bars have been placed round as before mentioned.

The "electro" generally requires some hammering upon a level iron slab to bring up "sinks" (Lecture II.), and the leveling of the back is generally done by a special surfacing lathe, as in the case of stereotypes by the plaster process. There is often a little after work to be done on the face of the electrotype, this being done by a workman called a "picker," who must be deft in the use of engraving and soldering tools, and in the case of fine cut work it is desirable to mount electypes on solid blocks of type metal, and for this purpose one of the fusible solders referred to in the last lecture may be used; the top of the block and the bottom of the "electro" being both well amalgamated with the solder, then brought into close and solid contact while sufficiently heated. A sort of cold soldering is sometimes employed, the two surfaces being separately amalgamated with mercury, and then held in close contact by a press till the excess of the mercury has diffused into the mass.†

The casting of stereotypes in brass (the material used for the earliest stereotypes on record) and in other refractory metals, has not yet become general, although the extensive present use of rotary and other machines for printing and branding directly upon wood is likely to create a demand for iron and perhaps steel stereotypes.

Iron or brass casts can be readily made in sand or loam moulds, but in moulding it is so much more convenient to mould from an ordinary stereotype than from the type forme, that I have no hesitation in very confidently recommending this course. As moulding frames, two ordinary printers' chases may be used, one having register pins fitting into corresponding holes in the other, and both being furnished with a few cross wires to support the sand; but a gap should be cut away from the top of one to form an ingate. One part of Stourbridge clay and two of Bathbrick dust forms a very good mixture, and after this has been slightly damped, well rammed, and carefully leveled into the casting box, the pattern stereotype is oiled and is forced by a press into the soft surface. A little brick dust being sifted on to serve as a parting material,‡ the second chase is placed in position and filled with the moulding mixture, after which the frames are separated, the pattern removed and the mould is baked. For casting, the two frames may be conveniently clamped up in the ordinary stereotype casting box (Fig. 4), a few channels being cut for the escape of air.

The mould should be well dried, but not too rapidly, or it is rather liable to lose its face by a kind of granulation or scaling, and the metal should not be so hot as to cause "sand burning." On the table are moulds and casts which I have made to illustrate this method of working, and Mr. Peter Barry has been good enough to send me some very excellent casts which he has made.

Stereotypes in high steel might perhaps be made by casting in moulds of lime compressed dry, and I have obtained promising results by this method, but should such be required they could, I think, be made, even if of considerable size, by the "striking" method indicated in Lecture I.

I find that by using a piece of wet asbestos millboard as a material for making the mould, we can stereotype in brass or iron by a method quite comparable to the ordinary paper mould process, and I will illustrate this to you by making a cast in brass.

When the asbestos millboard, which may be about an eighth of an inch thick, has been wetted, it is pressed against the forme by means of a screw press (there is no need to work from a previously made stereotype in this case), removed, dried at a heat bordering on dull redness, and with a similar piece of plain asbestos millboard clamped in the usual stereotype casting box, with a bent iron wire gauge between them; the brass is then poured in at the top. In this case there is no need to warm the casting box, the slow conducting quality of the asbestos preventing all chilling of the metal.

The body of a cast made in this way is rough, and generally somewhat unsound, being cast against the spongy body of the asbestos millboard, but the face, which is cast in contact with the hard and compressed portions of the mould, is sound and good.

To show you what can be done in the way of typographic brass casting, Mr. Nettleton, of Barnsbury, has been good enough to send me samples of his cast brass type, both in the rough and finished; these, I understand, are cast in iron moulds.

The various photo-stereotype or photo-typographic methods do not come within the scope of the present lectures, but I have now the opportunity of showing you some Arabic printing types cast in matrices reproduced by photographic means from an impression taken from type of a larger size. In this case the reproduction was made for Messrs. Stephen Austin & Sons, of Hertford, by Mr. Alfred Dawson—so well known as a successful worker in photo-engraving methods, and I am told the cost was only a small fraction of what the expense would have been if punches had been cut.

I also have placed upon the table reproductions which I made some years ago of some letters from a book printed by Sebastian Gryphius, of Lyons, in 1539, and alongside them are the matrices and body mould. In this instance each letter, cut out of a photo-type block, was set separately in a level plate of metal, at the required distance and a thick electrotype cast was made of the whole. This was strengthened by a backing of soft metal, and when cut up it formed the matrices.

Celluloid, as a material for stereotyping, has been proposed by Jeannin, who makes his mould by mixing the soft unfused oxide of lead known as massicot into a stiff paste with glycerine, and if baked for about five minutes in contact with the forme, at about 120° Centigrade, the mould becomes hard, and separates. The celluloid is then softened at about the same temperature, and forced into the mould.

The same kind of mould answers well for making stereotype casts in the so-called Spence's metal (sulphur slightly hardened), an excellent composition of this kind being the following:

Sulphur............................	100 parts.
Finely powdered pumice stone......	30 "
Native sulphide of antimony........	4 "

It requires careful melting, as if over-heated the sulphur would pass into the viscous modification, and it should be well stirred before pouring.

The use of India rubber stereotypes has not gone much beyond their employment as hand stamps. The mould in which the rubber is vulcanized is generally made of a mixture of plaster of Paris and French chalk, the forme being "filled in" with soap, to insure easy separation. As only small casts are ordinarily made, it is convenient to mix the plaster and French chalk (equal parts of each answers very well) to a paste with water, and to spread this on a level surface, and to force the forme into it. At other times the bed of plaster is moulded on the type with two successive pressures, the first with a cloth covering, and the second without a cloth, these operations requiring a means of keeping register, and being similar to Mr. Clay's method of moulding in wax for electrotyping.

If a large mould is required, nothing is better than M. Jeannin's composition of massicot and glycerine, while simple plaster of Paris answers very well, especially if after drying it is hardened by saturation with a solution of shellac in alcohol. The mould having been obtained, is dried and warmed, and some uncured rubber, mixed (by strong rollers) with about one-tenth its weight of sulphur,* is softened by a gentle heat, and forced into the mould, after which the whole is exposed to a heat of 140° to 150° Centigrade for about half an hour, during which time the sulphur reacts chemically on the rubber, and what is called vulcanization results, the rubber no longer becoming plastic by heat. Hot presses for the vulcanization of rubber stamps are now sold at a moderate price, or a simple arrangement, which I showed in this room nine years ago, may be used. It consists of a cast iron fish kettle, upon the bottom of which is cast a slab of type metal an inch thick. Inside the kettle is placed a small press, like a copying press in miniature. By the side of the press stands a small iron cup, containing glycerine, and in this fluid is immersed the bulb of a thermometer, the stem of which projects through a hole in the cover of the kettle. By means of a small gas stove, heat can be supplied to the apparatus, and it is easy to so adjust the gas supply that the thermometer shall indicate a tolerably constant temperature of say 140° or 150° Centigrade, the slab of metal serving as an equalizer of heat.

Mr. John Leighton introduced rubber stereotypes about twenty-six years ago, and his firm has been good enough to send here samples illustrative of their manufacture and use, a subject which in itself might well occupy a whole lecture. At one time experiments were made as to the practicability of using rubber stereotypes on rotary printing machines, as they would easily adapt themselves to the required curves, and might be expected to save power in the working of the machines. Fatty ink soon softens and destroys rubber stereotypes, so that an ink made by dissolving an aniline color in glycerine is generally used. These will generally fade rather rapidly on exposure to the light, but by dissolving nitrate of silver in glycerine we have an ink which does the reverse. At first it gives a colorless impression, or nearly so, but on exposure to light it gradually becomes deep brown.

Elastic stamps, which can be used with the ordinary printer's ink, can readily be made of any required hardness with a gelatinous composition similar to that used for the ordinary printers' inking rollers. The making of these is a very simple matter indeed. A piece of very thin sheet lead, such as is sold for covering damp walls, say about an eightieth of an inch thick, is slightly oiled, laid over the forme, and beaten with the moulding brush until a satisfactory impression is obtained, after which it is laid on a level, flat surface; a border is placed round it, and a melted gelatinous mixture is poured over it; any mixture, such as is used for printers' roller composition, will serve, although something rather harder will often be required. By soaking a fine hard gelatine (Coignet's silver label gelatine, for example) in water till it has absorbed about its own weight of water, and then melting it with half as much glycerine, a serviceable hard composition is obtained, but with some tendency to shrink, which can be met by adding more glycerine, and heating for some time in a flat dish over boiling water, so as to evaporate some of the water.

Under the head of auto-stereotyping I propose to deal with a few of those methods in which lines are cut out or indented on a level surface by some sort of sketching or writing action, this writing being then used as a mould in which is cast a stereotype, from which the writing or drawing may be printed, and of late years such methods have come much into use, and have acquired considerable importance.

If one simply takes a blunt style, and, while using some considerable pressure, with this makes a sketch on a very soft paper board * or a blotting pad, a mould is obtained which, if cast from, as in the ordinary paper process of stereotyping, yields a block that can be rapidly deepened by the engraver, and may serve very well as an extemporaneous illustration for a newspaper, and as the material for this sort of thing is always at hand in a newspaper office, it is a very convenient method to employ when only a rough sketch is required, and by a very simple expedient, the labor of cutting away the whites of such a cast may be obviated, provided there is no objection to the sketch appearing on a ruled or cross-hatched ground. Before making the sketch, a hard impression of a lined, dotted, or cross-cut block is made on the paper pad, † and the sketch is afterward made with the style. A cast now being taken, the ruling or dotting gives sufficient support on the whites, and the sketch shows as lines on the tinted ground.

The above is essentially a process for rough or hasty work of the crudest character, and we now pass on to one of the earliest methods, and perhaps the best of all if perfection of result is considered, namely, the glyphographic process, invented by Edward Palmer ‡ about 1841. A thin coating of wax, whitened by a suitable pigment (white lead or other heavy lead compounds answer best), is spread on a blackened copper plate, § and the sketch is made on this with a point, so as to lay bare the black copper, the dark lines thus produced showing the artist the progress of his work. Any lettering may be done with stamps or types, the wax ground being softened by a little heat if necessary. The extended whites are now raised by the building process already described in reference to the wax mould for electrotyping, the hot pen there mentioned being used for filling in between the finer lines, and during this process any false line may be covered; after which an electrotype cast is made from the wax mould. Binger, in his "Glyphographie," published at Amsterdam in 1850, gives as fine examples of work by this process as any since done. It is now very extensively employed, and it is understood to be substantially the method by which several well known firms produce blocks. As it would be in many cases obviously inconvenient to submit the traced wax plate itself as a proof, a photograph is often sent.

There are several processes roughly classed as "clay" processes, in which a mineral mixture is used on the copper plate, and a cast is made directly in stereotype metal from the tracing made on this surface, and I will illustrate to you the form of this process which I have found to work best in my own hands.

I now take a plate of copper which has been roughened by glass paper blackened by a solution of perchloride of platinum, rubbed over with white of egg, and then flooded with a whitewash composed as follows: Stereotype paste, as given on p. 12365, Lecture II., 6 oz.; whiting, 24 oz.; water, 3 pints. Enough should be allowed to remain on the plate to form a layer 1-20th to 1-30th of an inch thick, and the plate is then set in a horizontal position to dry. A design can be readily traced with a point through the friable ground, and after the mould has been dried at about 200° Centigrade, a cast is made in the casting box ordinarily used for the paper process. Apart from the operation of deepening the whites of the block and the making of the sketch, the whole work can be performed in ten minutes or so. The mixture used for coating the plate may serve to raise the whites on the mould, this preparation being put on by means of a pipette, but such a course is not to be recommended, as it involves delay in drying, and there is increased chance of the coating leaving the copper. The most essential point is the use of albumen on the roughened plate, this enabling a friable mixture to hold on sufficiently for practical purposes.

Closely analogous to the autographic stereotyping methods are those in which a machine analogous to a typewriter is used to make a matrix, letter by letter, on such a material as flong, wood, or soft dry pulp

* The French electrotypers always place gauges on the clump marks when pouring on the backing metal, and, just as it is on the point of solidifying, the platen of a press is brought down on it. In this way the need of planing the back is often obviated, and the tendency to sinks and irregularities of the face is diminished. Of course, when the above course is taken, the tinned shell must be placed on an accurately planed surface. The French method is better adapted for rather thick than thin shells.

† As a means of fastening types together to form solid stamps (stereotypes in the sense in which Didot first used the word), the mercurial method of soldering is admirable, and it is also fairly satisfactory for fixing a letter into a stereotype plate provided that the fit is accurate.

‡ As the pattern is generally forced in so as to be level with the surface of the mould, a sheet of oiled paper may be laid over instead of using parting sand.

* Mixtures of this kind can be obtained where materials for making rubber stamps are sold.

* A thick "wood middle" or pulp board answers well.

† An assemblage of ordinary brass "rules," plain, dotted, or waved, may be used.

‡ Palmer kept a well known philosophical instrument shop in Newgate Street, and was succeeded by Horne & Thornthwaite.

§ The clean copper can be blackened by a weak solution of silver nitrate or platinum tetra-chloride.

boards, and in Guillot's "Graphitype" (Lecture I., p. 12343) we have the parent of all such methods. The weak point in all these processes is the difficulty of making corrections or alterations, and no printing method which does not provide for this is likely to be generally accepted: the only matrix method which gives this facility in a high degree being the matrix setting method of Herhan (Lecture I., p. 12343), which method, if operated in connection with a typesetting machine, should be quite as rapid as the typewriter methods, and it allows alterations as readily as when ordinary types are used.

AUTOMATIC APPARATUS FOR THE MANUFACTURE OF CARBONATED WATERS.

THE manufacture of carbonated waters, which hardly seemed as if it was to leave the domain of pharmacy, has so increased that it now constitutes a very important industry. In nature, we find a large number of mineral waters that contain enough carbonic acid gas to give them a pungent taste and to make them effervesce in the air. Such are the seltzer water of Germany, the Saint Galmier and Vichy waters of France, the spa of Belgium, etc. The name seltzer water has been given to a sort of imitation of the natural carbonated water obtained by dissolving a large proportion of carbonic acid gas in pure water. This name is not very *apropos*, for natural seltzer water contains something else besides carbonic acid gas. It would be better, then, to call this beverage simply carbonated water. This water is now used in large quantities mixed with wine or sirups. It differs from common water only in containing four or five times its volume of carbonic acid gas, which communicates to it stimulating properties that in many persons aid the action of the stomach.

The carbonic acid that serves to prepare this gaseous water is obtained by causing sulphuric acid to act upon chalk. Chalk is carbonate of lime, that is to say, a substance resulting from the combination of carbonic acid with lime. As sulphuric acid has more affinity for lime than carbonic acid has, it combines with it to form sulphate of lime and sets free the carbonic acid in the state of a gas.

Fig. 1 represents the installation of a new automatic apparatus constructed by Mr. Durafort, which produces carbonic acid through the use of bicarbonate of soda instead of lime.

It consists of a gas generator and of a siphon and bottle filling device.

The generator has the form of a gasometer. It is seen in section in Fig. 2.

Two iron uprights fixed to the tank by bolts support a cast iron cross piece provided with two pulleys. Two cords are attached to the gas holder, R, on the one hand, and to two counterpoises on the other. In the interior of the tank, D K, there is a leaden reservoir, into which acidulated water is introduced through the aperture, D. With the holder, R, there is connected a leaden receptacle, B, into which bicarbonate of soda is introduced through the aperture, C.

It is easy to see how the automatic production of gas is effected.

As soon as gas is taken from the cock, J, the holder descends, and the bicarbonate of soda, brought into contact again with the acidulated water, reproduces the gas in measure as it is consumed.

The gas stored up in the holder is sucked out by the pump, which, at the same time, takes a certain quantity of water from the reservoir. This suction is regulated by a cock, S. The pump forces the mixture into the sphere above, where a device, revolved by the inflow, finishes the saturation.

After the desired pressure has been obtained, say 12 to 14 atmospheres for the siphons, or 6 to 8 for the bottles, the filling is begun.

The indicating flask, I, shows the quantity of gas contained in the generator, as well as the quantity of liquid sucked from the reservoir by means of the pipes, J and L.

The bottling is effected through the annexed apparatus, which is easily maneuvered. Two rods actuated by pedals cause the mouth of the bottles or siphons to bear against a rubber collar for the filling. The communication with the saturator is regulated by a cock independent of each system. The filling is kept up by means of the pump, which is actuated either by hand or by a motor.

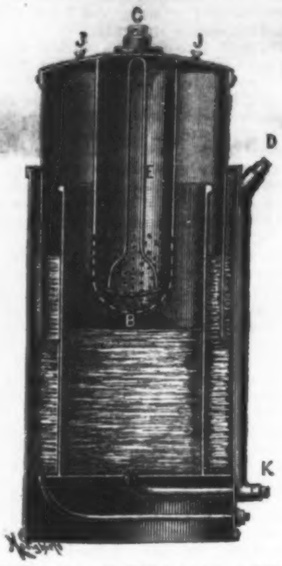


FIG. 2.—SECTION OF THE GAS GENERATOR.

This apparatus, as may be seen, is very simple, and is capable of filling 1,000 bottles a day.—*La Production Industrielle.*

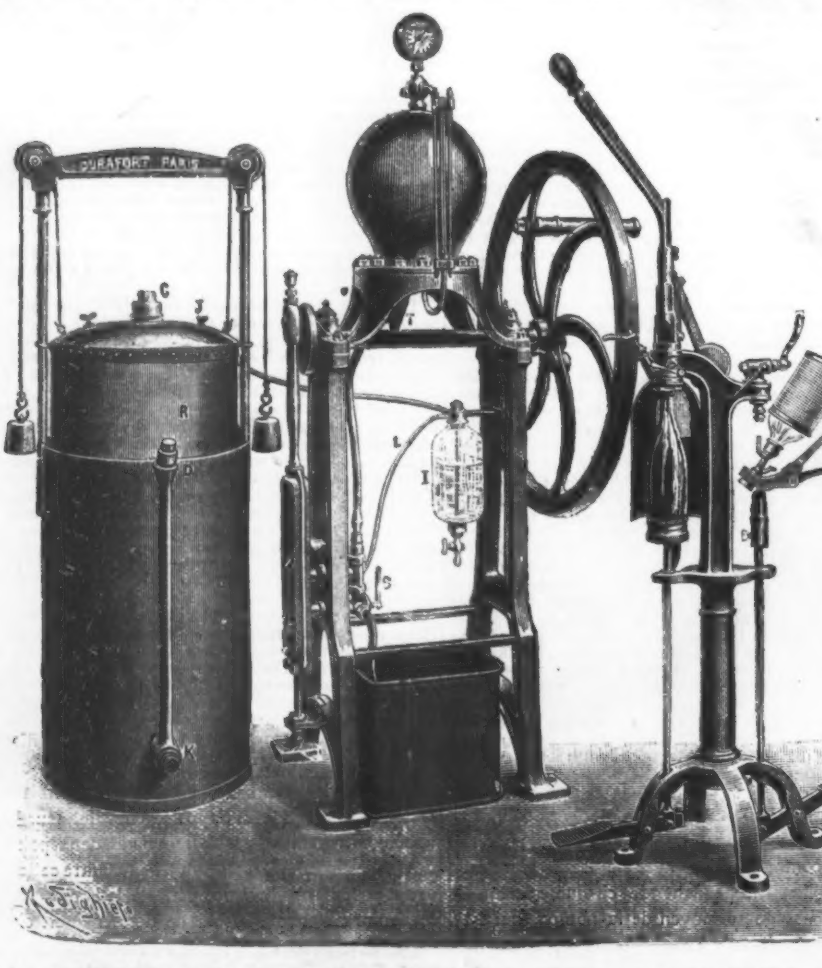


FIG. 1.—AUTOMATIC APPARATUS FOR THE MANUFACTURE OF CARBONATED WATERS.

GLYCERINE.

MANY years ago, in an obscure mining village in Sweden, the apothecary, while making lead plaster in the ordinary way by heating olive oil with litharge and water, chanced to notice that the liquid which was mingled with the pasty lead compound had a strangely sweet taste. On further investigation he found that the sweet taste was caused by the presence of an oily liquid which was dissolved in the water. No such substance was described in the books of the day. Evidently a discovery had been made. The discoverer, although poor and with slight advantages of education, was a man of more than ordinary ability. Already he had attracted the attention of the learned men of the day by publishing his quaint chemical theories of combustion (*Ueber die Luft und das Feuer*), nor was this his first discovery of a substance hitherto unknown to science. We can easily imagine, then, with what enthusiasm Scheele—for that was his name—plunged into the study of the strange liquid in the occasional respite that was granted him from the pestle and the dispensing counter. He soon found that the sweet substance was not the product of olive oil alone, but that other oils and fats would yield it under the same treatment, so he named it the "sweet principle of fats," or "oil sugar." Soon after, his work was cut short by death. More than a century has passed since Scheele's discovery, yet it is scarcely fifty years since "oil sugar" was found to be of practical value, except, perhaps, for a limited use in medicine. Many famous chemists had taught the world much as to its nature and production, had given it the more formal name of glycerine, derived from a Greek word meaning sweet, but to the every-day world the substance remained only a curiosity. Nowadays, every one is familiar with the clear, thick liquid so commonly used for toilet purposes. Its soothing and softening effect on dry or inflamed skin is the quality by which it is best known in most households, but few people have any idea of the variety of purposes for which glycerine is used. This will not seem strange when we find how many valuable properties are possessed by this remarkable liquid. Among the most striking of these are its great solvent power, its chemical stability, and its sweetness. Besides these, it is not indigestible, will not evaporate, and, owing to this and its hydroscopic qualities, will prevent drying and hardening of materials with which it is mixed. These peculiar qualities make it most valuable in the preparation of medicines and various food products, as preserves and mustards, likewise in beer, wines and other bottled goods, where it is said to act as a preservative. The fact that strong solutions of glycerine and water will not freeze in the lowest winter temperature has its use in our "wet" gas meters. In short, the list of purposes to which this most useful liquid is put is almost exhaustless. Among the more important industries in which it is used are vulcanizing India rubber, silvering and gilding glass, dressing leather for kid gloves, preserving anatomical and botanical specimens, and the manufacture of what is, perhaps, the most powerful explosive known to science—without whose aid some of the grandest triumphs of modern engineering would have been impossibilities—nitro-glycerine. Scientifically considered, glycerine is most interesting. Mention has already been made of many of its physical characteristics.

In a pure state glycerine is somewhat more than a fourth heavier than water (1·269). After long exposure to a freezing temperature it will deposit rhombic crystals resembling those of sugar candy. Strangely enough, when quickly cooled to very low temperature —40 deg. Fahr.—it forms a gummy mass which will not harden nor crystallize. Indeed, it was not till 1867 that it was thought possible to crystallize it. The boiling point of glycerine is about 490 degrees Fahr. At this point it decomposes slightly. As already stated, glycerine will not evaporate at ordinary temperatures, but at the boiling point of water (212 degrees Fahr.) there is a perceptible loss. Pure glycerine will burn readily, if first heated to about 300 deg. Fahr., giving a pale blue flame similar to that of alcohol. Heated intensely it decomposes into acrolein, a most pungent smelling compound, one whiff of which is usually sufficient to fix it indelibly on the memory. To the chemist glycerine is an alcohol, being, like other alcohols, a hydrate of an "organic radical"—that is to say, the hydrate of a combination of carbon and hydrogen which forms salts as if it were a metallic element. From its chemical behavior glycerine can be considered a "tri-atomic alcohol," or tri-hydrate, with the formula $C_3H_5(OH)_3$, on the same analogy as sodic hydrate, NaOH, or calcic hydrate, $Ca(OH)_2$—the group represented by the formula C_3H_5 acting as a base and known chemically as glyceryl or propenyl. Just as we can make salts of a metal from the hydrate, so can we make salts of glyceryl in essentially the same way, although the methods employed are different. Nitro-glycerine, so called, is one of these salts of glyceryl, being an impure tri-nitrate ($C_3H_5[NO_3]_3$). By far the most important salts of glyceryl are oils and fats.

The majority of these are salts of glyceryl and organic acids. The principal of these acids, out of many which are present in our common fats, are stearic, oleic, and palmitic acids. We now understand how it was that Scheele made his glycerine. We remember that olive oil was the basis of his lead plaster. This oil is, in the main, glyceryl oleate

$$(C_3H_5[C_{18}H_{33}O_2]_3).$$

Hence the reaction between the lead and the oil and water can be expressed by the following equations:

$$\underset{\text{Glyceryl oleate.}}{2\,C_3H_5(C_{18}H_{33}O_2)_3} + \underset{\text{Litharge.}}{3\,PbO} + \underset{\text{Water.}}{3\,H_2O}$$

$$= \underset{\text{Glycerine.}}{2\,C_3H_5(OH)_3} + \underset{\text{Lead oleate (lead plaster).}}{3\,Pb(C_{18}H_{33}O_2)_2}$$

For many years this reaction was the basis of the manufacture of glycerine. Cheaper fats than olive oil, of course, were used, while traces of lead in solution were removed by sulphureted hydrogen. As the use of glycerine became more extensive, there arose the necessity for a cheaper method of production. Attention naturally was directed to the spent lye of the soap manufacturer, for soaps are sodium or potassium salts, principally of stearic acid, made by a reaction similar to that used in making lead plaster, but substituting caustic alkalies for litharge. By the method of soap manufacture, however, the liquors containing the glycerine are so contaminated by alkalies and salt, and are so diluted, that until recently it has not paid to recover the glycerine. A process which has proved most profitable has been invented to decompose animal fat directly into stearic acid and glycerine, by subjecting it to the action of superheated steam, at a temperature of about 300 deg. Fahr. The resulting glycerine is concentrated and purified by steam distillation, while the stearic acid, which much resembles wax, and in no way answers to our ordinary conception of an acid, is in great demand for candies. In this way thousands of tons of glycerine are made yearly, not to mention the immense number of excellent candles which are also products of the process.—*Popular Science News.*

AN ASTRONOMER'S IMAGINARY VISIT TO VENUS.

MR. GARRETT P. SERVISS, a member of the Brooklyn Astronomical Society and a frequent lecturer on astronomy and subjects connected therewith, writes as follows in the New York *Sun* of an imaginary visit to the planet Venus:

My fondest hopes were at length realized, and I set foot on the night side of Venus, according to the terrestrial calendar, on Dec. 5, at two o'clock in the morning, Washington mean time.

It was the dead of night, for, as I have said, I had come upon the dark side of Venus, and everybody now knows, thanks to that sharpsighted Italian, Signor Schiaparelli, that Venus keeps one of its sides always turned from the sun, behaving toward the god of day in this respect just as the moon does toward the earth. The starlight was very brilliant, and well above the horizon shone a star of extraordinary splendor, accompanied at close quarters by a small companion star. A thrill ran through my frame as I recognized in these the earth and the moon, now become for me only distant members of the sidereal host. It was the time of Venus' inferior conjunction, that is to say, the planet on which I was standing had arrived at that point in its orbit where it was situated exactly, or very nearly so, between the earth and the sun. My distance from the globe that had given me birth was not less than twenty-six millions of miles.

Making a rough mental calculation, based upon the earth's elevation above the horizon and its position among the stars, I concluded that I had arrived on the eastern side of the unilluminated hemisphere of Venus not far from the equator, and twelve hundred miles or so from the nearest border of the sunshine.

It was intensely, bitterly cold. I seemed to have been plunged into a bath of ice, yet a dead calm prevailed. I had never seen the heavens appear so brilliant. Every star was as small as a needle point and as dazzling as an electric light. The steadiness and clearness of the air rendered my vision almost telescopic, and I could easily separate some of the wider double stars.

In a few minutes the tingling of my ears and cheeks warned me that they were freezing, and I pulled my heavy double-faced sealskin cap down over my face and neck and jerked up the collar of my fur coat, leaving only a peephole for my eyes. Then, to keep the blood in circulation, I started on a brisk walk, not choosing any direction, for how was I to tell where I should come out? Notwithstanding the fearful cold, there was no snow, but that did not surprise me, since I knew this part of Venus was never exposed to the sun, and consequently there could be no formation of clouds here. I ascribed the perfect stillness of the air to the same cause.

The ground was rough and bare of vegetation, and I frequently stumbled, and each time I did so my foot, dashing against the soft shaly rock, scattered a jingling shower of mica flakes which glittered in the starlight like scales of silver. There was no sign of any living thing. I seemed to be absolutely alone in this sunless world. The sight of the earth up in the sky comforted me a little, and I stopped once to gaze at it. For a minute my thoughts ran on the busy life that was throbbing there in the bright sunshine. Then I turned and examined the horizon all around. In one direction only was it broken by hills, and that was the direction I chose. It was long before I could accustom my nerves to the noise I made in walking. The tension of the cold still air was so great that the slightest cracking under the soles of my fur-lined shoes startled me like a pistol shot.

Suddenly as I trudged along with my face withdrawn as far as possible from the cold, I became aware that some living thing was by my side. A good deal surprised, not to say alarmed, I peeped sideways at my unexpected companion, and instantly terror had possession of me. It was a creature much like a man in stature and outward form, but with an enormous face, round and hairy, a mouth resembling a gorilla's, fanglike teeth, which it showed in a horrible grin, huge, cat-like eyes, and long crooked arms and legs. It wore no clothing, being thickly protected with shaggy hair, and as it timed its silent steps to mine, and haunching its big shoulders, sidled up to me in the gloom, my hair rose on end. I thought of my revolver, but I was so wrapped up against the cold that I could not reach the weapon.

[The astronomer here describes an imaginary and harmless encounter with a number of these strange inhabitants of Venus, and how they lived in caverns on vegetables which grow there aided by the heat of the planet from its own interior, and how he made one of them named Jupi his servant.]

By watching the slow motion of the heavens I was able from my knowledge of the velocity with which Venus moves in her orbit to form a pretty correct idea of the lapse of time. My watch kept faithful account of the hours, but without sunset or sunrise the larger divisions of time would have been lost to me but for my calculations. Venus makes a revolution around the sun in a period of $224\frac{3}{4}$ terrestrial days, nearly; in other words, that is the length of her year. Of course as she performs only one rotation on her axis while describing a circuit about the sun, she always keeps one face directed toward the sun. But the same apparent annual revolution of the heavens which we witness on the earth occurs on Venus, being sharply shortened in time in the proportion of the length of Venus' year to the earth's year. As I saw the earth with the stars surrounding it sink behind the western horizon while other constellations appeared in the east, I was able at any time to calculate what part of her orbital journey of 224 days Venus had performed since my arrival.

More than three months had thus elapsed, and I had beheld five full signs of the zodiac disappear, while five others rose to fill their places, when I determined to put an end to my stay and make my way as best I could to the sunward hemisphere of Venus. No sooner had I made known my intention of going away than Jupi gave evidence of a determination to accompany me. I offered no objection to this, for he could be of great assistance, to say nothing of the value of his mere companionship in such a journey as I was about to undertake amid the perils of an unending night and through a trackless and frozen desert. One of the plants growing in the deeper caverns possessed extraordinary nutritive properties, and I calculated that it would be easy to carry a sufficient supply to last us at least eight weeks.

Guiding our course by the stars, I followed a line parallel to the planet's equator, and so advanced straight toward the east. I knew that the distance to the border of the sunlighted hemisphere could not exceed 1,200 miles as the crow flies, as we say on the earth. The absolute cloudlessness of the sky was a great point in my favor, since it secured me against any interruption of the observations on which the correct determination of the direction of our journey depended. Jupi did not suffer from the excessive cold, but I was greatly annoyed by it. When we had to sleep, which we did as seldom as possible, we were usually successful in discovering some crevice in the rocks which could be fortified in part against the cold. Our course led directly away from the inhabited hills, and we met with no living thing of any kind, either animal or vegetable. Luckily for us the country was upon the whole level, so that our progress was even more rapid than I had dared to hope. Occasionally we came upon a frozen lake, as brittle and smooth as glass.

When we had been traveling about a week and had covered, according to my computation, not less than 235 miles, an incident occurred that filled me with wonder, although it proved to be only a prelude to still more astonishing, in fact to incredible things. A pile of seeming rocks in a broad plain was transformed by our approach into the ruins of a massive building. I was speechless with astonishment upon making this discovery. It required but a glance to see that this had been no rude construction, but a masterpiece of architecture, the work of a highly civilized people. I quickly convinced myself that it was not the remains of a temple, but more probably of some public building devoted to the purposes of business. Further inspection revealed other ruins lying around us in the half-light of the stars, and then the truth dawned upon me that we were on the site of an ancient city. The conclusion was irresistible that some tremendous catastrophe must have brought about the present sunless condition of this part of the planet, for I was certain that in the dark and frozen state in which I saw it no race could ever have accumulated either the knowledge or the wealth necessary to the building of a city such as this had been. . . .

We had hardly resumed our journey before I noticed, low in the eastern sky, a phenomenon that made my heart beat quicker. One would have said that day was about to break there. Close to the horizon lay a faint band of light. The lightest touch of the brush could not have imitated its transparency and tenuity, yet it caught the eye at once. I knew it was no sunrise, for, whatever might have been the case in long past ages, the sun could never rise to this side of Venus now. Yet it was sunshine, sure enough—an unending twilight that never either brightened into day or faded into night. When I began to reflect upon it, I was rather surprised that I had not seen this light before. My distance from the edge of the illuminated half of the planet had never exceeded 1,200 miles, and was now rather less than 1,000, and if the atmosphere of Venus closely resembled that of the earth in density and height, I thought I should have noticed some appearance of twilight even at the greatest of those distances. I concluded, therefore, that the atmosphere of this planet was either of less height than the earth's, or else varied from it in its refractive index. My aneroid barometer, adjusted to terrestrial conditions, would have settled the question of density, but it had been broken by my fall into the cave of the Illoe before I had made any observations with it.

As we hurried forward we had the twilight sheen always before us, and gradually brightening as we approached. Slowly, but surely, we were making our own sunrise. The ground remained remarkably level and unobstructed, and our progress was surprisingly rapid. After a while the twilight mounted higher and increased in brightness, so that the stars in the eastern sky began to pale, and our shadows, faintly outlined, streamed far behind us as we walked. It was a strange sight this frozen world, whose real ghastliness of aspect now for the first time appeared in the dim white light of dawn. Presently, low down on the horizon, a long, narrow streak of light as red as blood appeared, and I exclaimed in ecstasy: "The sun! the sun!" But we had yet a great and painful journey to perform before we should actually see the sun. As the eastern light brightened Jupi exhibited great astonishment, but I could not perceive that he experienced any fear, although his complete confidence in me would have made him face without flinching any danger which did not daunt his master.

Thus we pushed on, and gradually a beautiful scarf of delicate green was stretched above the red light. Then of a sudden, having surmounted a steep rise of ground, I found myself rooted to the spot by a spectacle such as mortal eyes had never beheld. "Good heavens!" I cried, "this world is on fire!"

Ahead of us, and far to the north and south, the horizon was all ablaze. My heart sank within me. But in a moment fear gave place to fresh amazement. If that was fire, surely these were the strangest flames that ever heat gave birth to. Looking more narrowly, I thought I could perceive the peaks of a lofty range of snow-clad mountains amid the blaze. "There is no smoke," I said. "It cannot be a conflagration," and we hastened on again. At length the splendor of the spectacle surpassed description, and then the truth burst upon me. It really was a mighty mountain ridge that we were approaching, and the orange and red sunlight, striking upon its icy flanks and glittering pinnacles, was broken into rainbows of fire. Jupi, so far from being terrified, danced and shouted with pleasure at the wonderful sight. Then he threw himself on his knees and bowed his head, and afterward made me understand that there was a tradition among his people of the existence of these mountains and of the fire god that dwelt upon them.

We were both now in a fever of anticipation, and we fairly flew down upon the broad, level expanse that separated us from the nearer ranges. In two forced marches of nearly ten hours each we approached so near to the resplendent mountains that their general features could be readily discerned. Vast glaciers stretched out to meet us as we advanced. Presently we came upon hills of broken ice that formed the foot of the line of glaciers. Its sharp edges cut our hands like knives.

We clambered over and upon it as best we could, and from this elevation the mountains appeared startlingly close. The twilight had brightened to such a degree that many details of the wonderful landscape were visible even at a considerable distance. And now I perceived that there was an entire absence of rock in the mountains. They were evidently solid ice from base to summit. A few light clouds floating among the glittering peaks, rose-tinted by the still hidden sun, suggested to my mind the mode of origin of this great barrier between the night and day sides of Venus.

"I ought to have foreseen this," I said. "I should have known that the vapors from that sun-smitten hemisphere would be congealed into snow and ice as soon as they drifted across the border dividing perpetual day from perpetual night, and that in the course of ages a giant range of ice mountains must of necessity mark the line of division. No doubt, the dazzling spots that our astronomers have seen near the poles of Venus were caused by the glitter of these mountains that on one side face the sun and on the other an eternal night."

How to cross the range was now the problem. Before us rose glaring precipices thousands of feet high. While we stood hesitating what to do, I saw a huge mass detach itself from a tall white peak that seemed to pierce the sky, and fall upon the solid slopes of ice far beneath, where it was dashed into iridescent spray. Yet we pushed forward, clambering with many a perilous fall and slide over the rough and slippery ice, until at last, by following the trend of a glacier-like expanse, we found ourselves shut in on all sides by crystal cliffs. I am thrown into despair when I try to describe the scene. It was a circle of jeweled Alps by which we were surrounded. Here was a giant sapphire, its cold, polished blue flanks rising 10,000 feet into the sky, and there tipped by the upper light with amethyst. A mighty dome just beyond shone with all the glorious tints of the emerald. The lesser summits were girt about this pair, blazing like diamonds in the auroral glow, while far behind them all, lifting its unrivaled head so high that even from the bottom of our glacial valley its pre-eminence impressed the beholder, was a massive summit whose frosted sides sparkled and coruscated in the prismatic beams of the morning until our dazzled eyes sought refuge from the unbearable splendor of the scene. Since at no time could the solar rays reach these mountains with sufficient intensity to produce much melting of the ice, I concluded that the precipices and pinnacles around us were formed by the breaking down of the icy masses under their own weight, just as the vast glaciers at their feet resulted from the outflow caused by the pressure of the superincumbent burden of ice. Thus, as the deposit continued to grow year after year, constant changes must be taking place under the ceaseless operation of gravity.

How we crossed the mountains I hardly know. Certainly without the aid of Jupi, whose strength and activity were prodigious, whose feet were formed by nature to cling to smooth surfaces, I could never have accomplished the transit. It must have occupied us many days, and a thousand times our lives were not worth the snuff of a candle. At last we emerged upon an icy plateau, and with a cry of mingled gratitude and admiration I once more beheld the sun, resting on the horizon like a ball of red fire.

The ice toward the east was covered with hummocks. Pushing our way through these for many weary miles we were at length greeted with the spectacle of a vast expanse of water in the distance crowded with icebergs and floes and extending further than the eye could reach. Finally we attained the edge of the ice sheet and found ourselves standing on the verge of a blue precipice that fell away a sheer 500 ft. into the deep water. We skirted the precipice until we found a place where a mass of the ice had broken off, leaving a sloping descent to the water half a mile long. I determined to make my way down this precarious pathway to the sea. Even Jupi's feet could not cling to the steep, glaring ice, and I began to cut steps with my heavy knife. While thus engaged my foot slipped and I lost my balance. I threw out my hand and grasped Jupi's leg, and he fell upon me. Then began the most awful experience of my life. Clinging to one another, we darted down the slope, gathering speed with every rod. The air hissed in my ears as we shot through it, and I do not believe more than a minute elapsed before we struck the water, and, almost rebounding from its surface, amid a cloud of spray we sped outward at least two rods from the shore. I am a practiced swimmer, and Jupi swam by nature, like a dog. We struck out together to regain the ice.

At this instant a shout startled me more than the fall of an iceberg would have done. I glanced over my shoulder, and was astonished to see a boat rowed by six or eight men rapidly approaching us. A man sitting in the stern signaled with his hand, and in another minute the boat was alongside, and both of us were hauled aboard. The officer in command, after looking at us with great curiosity, spoke a few words, but of course could not make us understand. We were quickly rowed to a large ship which lay close to the ice, concealed by a projecting point from the top of the precipice where we had been. Our reception on board the ship was accompanied with demonstrations of the greatest surprise and curiosity. I concluded that our rescue had been purely an accident, the boat having chanced to be skirting that part of the ice where we had fallen into the sea at the moment when our plunge was made. I was greatly struck by the peculiar appearance of the people into whose hands we had fallen. They were of about the ordinary stature of terrestrial men, and had a very beautiful olive complexion, black hair, black, sparkling eyes, heavy black eyebrows, black beards and mustaches, aquiline noses, and a quick, smart way of moving and speaking that seemed to betoken superabundant physical energy. Their dress, mostly composed of fine furs, and the careful manner in which the ship was heated, gave evidence that they were natives of a far warmer climate.

To cut short the story of a long adventure, it was an exploring expedition that we had met, which was on the point of returning to a sunnier clime after a vain attempt to penetrate the icy barrier over which Jupi and I had made our way. Within a short time after our arrival the ship began to thread her way through the floes and bergs toward the east. She moved rapidly and smoothly, and was steered with great skill. I learned afterward that her engines were driven by

electric power. In fact, it required but a short acquaintance to prove that my new friends belonged to a highly civilized race, who in many respects had distanced the ingenious inhabitants of my own planet in the subjugation and utilization of the powers of nature. The ship was of aluminum or some similar metal, and carried with ease an enormous burden of supplies, scientific instruments and appliances adapted to the purposes of the expedition. I had never seen a vessel so elegantly fitted up. Her commander and all her officers were the most courteous persons I had ever met. Yet they would not, and in fact did not, attempt to conceal the devouring curiosity that they felt concerning me. It was evident that their finding of Jupi and myself was regarded by them as a very great compensation for the disappointment they had experienced in failing to penetrate the ice. While we picked our way for hundreds of miles through the floating ice, following the most intricate channels, amid scenery which, in many respects, resembled that of our own arctic regions, the commander of the ship and I strove to reach a common ground of intelligent communication.

Clearly the best way to attain our object was for me to learn his language, and both teacher and pupil being spurred on by the liveliest curiosity, this did not prove either a very difficult or a very long task. I was astonished, as my knowledge of the language increased, to find in how many ways these people of Venus had outstripped us in the race of civilization, but I observed with much satisfaction that there were a few things in which we were ahead of them. They were not good astronomers, since the peculiar law of the rotation of their planet, by keeping the sun forever above their horizon, hid the glories of the starry heavens from their sight. Moreover, their skies were covered with clouds much of the time. Yet they had invented telescopes, and had discovered the existence and the motions of the planet Mercury, which revolves within the orbit of Venus, and occasionally transits the disk of the sun. They were also well acquainted with the phenomena of the sun's surface, which they could study to better advantage than we can, owing to their greater proximity, but as Venus has no satellite, and consequently no solar eclipses ever occur there, they knew nothing of corona of the sun, which we on the earth behold surrounding the orb of day when the solar globe is hidden behind the moon. Singularly enough, they knew of the existence of only a few of the brightest stars, although with the aid of their telescopes they might have learned much about them, for, as is well known, a powerful telescope will show the stars even in broad day.

What little they knew of the sidereal firmament had been gathered from the meager and incomplete reports of those who had been, like the members of the present expedition, close to the dividing line between the light and dark hemispheres, where, owing to the libration of the planet in longitude, a narrow region of its surface sees the sun half the time and goes sunless the other half. The orbit of Venus is, however, so near a circle that the libration amounts to only about 47 minutes of arc either way, so that the sun in this region never rises more than about its own diameter above the horizon, and but for refraction it would not rise even as high as that. Over a large part of the region, which in the neighborhood of the equator is only a little more than 100 miles wide, while it grows narrower toward the poles, only a part of the sun's disk is ever seen. I was disappointed, therefore, to find that my friend, the commander, knew nothing of the earth, and this fact rendered all the more difficult the task of convincing him that I was an inhabitant of another planet. He accepted my story of how Jupi and I had come to the place where he had found us, mainly because he was able to conceive of no other way in which we could have got there, and both of us possessed racial characteristics which convinced him that we were not inhabitants of any of the known countries of Venus. But to believe that one of us had fallen out of the sky, so to speak, was too much for his credulity, and I certainly could not blame him for doubting so improbable a story. I was able, however, to shake his incredulity by showing him that I was familiar with the appearances of sun spots, which fact of course carried the necessary implication that I had not spent my life where the sun is never visible. Still I saw that I had not removed all doubt from his mind.

(To be continued.)

PHOTOGRAPHIC EQUATORIAL TELESCOPE.

SIR HOWARD GRUBB has constructed four complete photographic equatorials for the observatories of Greenwich, Capetown, Melbourne, and Mexico, while he has also fitted photographic telescopes to the existing equatorial mountings at Oxford and Cork, and has supplied a photographic object glass to the observatory at Sydney.

All the photographic telescopes above mentioned are of the standard type agreed upon at the Paris Congress, namely, refractors of 13·1 in. aperture and about 11 ft. focal length, the dimensions chosen being those of the photographic telescope at the Paris Observatory constructed by MM. Henry, and with which those astronomers have done such admirable work.

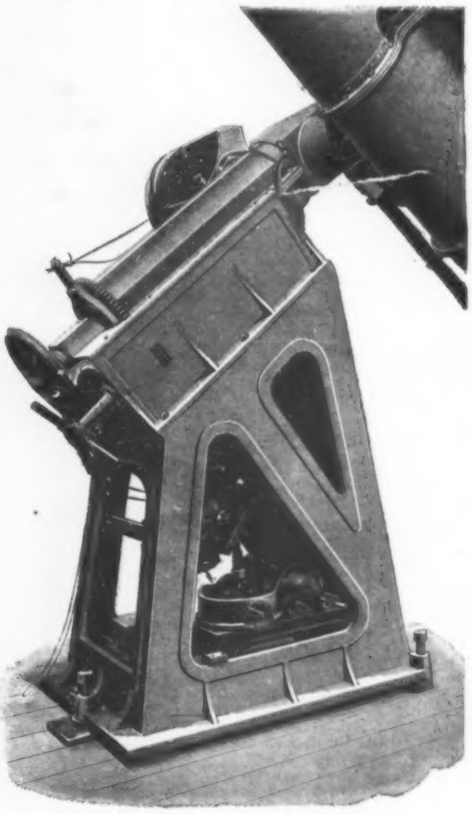


FIG. 2.

FIG. 1.

EQUATORIAL PHOTOGRAPHIC TELESCOPE FOR THE MELBOURNE OBSERVATORY.

We illustrate one of the complete instruments, namely, that constructed for the Melbourne Observatory. Our engravings have been prepared from photographs of the instrument taken while in the works at Dublin. We mention this as it accounts for the manner in which the instrument is shown in Figs. 1 and 2 without its regular masonry foundation.

Besides being provided with an object glass corrected for the actinic instead of the visual rays, a large photographic telescope, in order to do really satisfactory work, must have other special features, and of some of these we propose now to speak.

In the first place, in order to render possible these long periods of exposure which are essential in photographing the fainter classes of celestial objects, it is necessary that such a telescope should be capable of being used on an object for a considerable distance both before and after its passage of the meridian. In the Paris telescope of MM. Henry, this is secured by the adoption of the so-called English type of equatorial mounting, while in the telescope now under notice, Sir Howard Grubb has attained the same end, partly by making the distance between the axis of the telescope and the polar axis greater than usual and partly by adopting a special form for the framework and upper bearing of the polar axis, these parts being so designed as to allow of circumpolar motion of the instrument for objects of very high altitudes.

Of course, the feature we have just mentioned necessitates a very heavy and solid mounting, for the fact of the telescope being further removed from the polar axis involves the use of a stronger crosshead and heavier counterweights, these latter, moreover, being further increased by their being required to balance not only the photographic telescope itself, but also the large guiding telescope which is attached to it, as shown in Fig. 1.

The clamping and driving arrangements, etc., must also be stronger than in a telescope of the same aperture for ordinary visual work.

The necessarily heavy construction of a large photographic telescope to which we have just called attention in its turn renders it desirable that everything possible should be done to limit the frictional resistances of the instrument. For this purpose Sir Howard Grubb has, in the type of telescope under notice, adopted a special mode of supporting the polar axis. Instead of using the ordinary arrangement of friction roller or rollers at the upper end of the polar axis—these rollers bearing on a cylindrical portion of the axis and revolving on axes parallel with the latter—he carries nearly the whole weight of the moving part of the telescope upon a single roller pivoted on a horizontal axis and mounted at the upper end of a vertical bar against the lower end of which weighted levers act.

The weights on these levers are adjusted so as to exert an upward thrust equal to the whole weight of the moving parts of the instrument, less some 50 lb. or so, this small load being allowed to rest on the fixed bearings, so as to insure steadiness.

A certain portion of the steel ring which forms the upper pivot of the polar axis is turned taper, and to such an angle that when the axis is mounted at its proper elevation—that is pointing toward the poles—the lower side of this taper steel ring is horizontal and its position on the polar axis is such that a vertical line drawn through it and projected upward will pass through the center of gravity of the whole moving part of the instrument. If now a roller working on a horizontal pivot be brought to bear on the under side of the conical ring and forced upward with a thrust equal to the whole weight of the moving part, it is evident that the whole instrument will balance on this roller, and the whole weight of the instrument, and not merely a portion of it, will be carried on the roller. In practice the upward thrust is made equal to about $\frac{15}{16}$ of the weight of the moving parts of the instrument, a weight of about $\frac{1}{16}$ being, as above stated, left to insure steadiness in the V bearings.

In the case of the telescope we illustrate, the roller on which the whole moving parts of the instrument rests is of steel, and about 6 inches in diameter. It is mounted on an axis $\frac{3}{4}$ inch in diameter, the bearings of which rest on four friction rollers, also about 6

inches in diameter, and having axes ⅛ inch in diameter, so that the frictional resistance is extremely small. It is to be borne in mind, also, that by adopting this mode of carrying the moving load, all tendency of the lower pivot of the polar axis to bear its bearings unequally is avoided, as there is no residual pressure either up or down.

We next come to a very important point, namely, the necessity of driving the instrument with such precision that a long exposure can be given to a photographic plate without any perceptible distortion of the star disks ensuing, and it is in designing and constructing the mechanism for securing this result that Sir Howard Grubb has attained such remarkable success. To give an idea of the accuracy of driving required, we may point out that with such a telescope as we are describing, the image formed on the photographic plate by a twelfth magnitude star would be about $\frac{1}{500}$ in. in diameter, and obviously a shift of $\frac{1}{1000}$ in. would be quite sufficient to seriously distort such a disk. But in such a telescope the shift of the image on the photographic plate, if the driving were stopped, would be at the rate of about $\frac{1}{100}$ in. per second, and thus it follows that if at any given moment the driving movement of the telescope should get even a tenth of a second in advance or in arrear, it would cause a serious distortion of the star disks.

The means by which Sir Howard Grubb has secured the wonderful accuracy of driving thus required are extremely ingenious. We shall confine ourselves here to speaking of the results obtained with them. These results have fully equaled the expectations of the designer, photographs taken with thirty minutes' exposure having shown the star disks quite perfect, proving that during that exposure the driving arrangements were at no time one-fortieth of a second in error. This result, moreover, was obtained solely by the automatic control of the apparatus, and without any aid or correction by an observer at the guiding telescope, and it is a result on the attainment of which Sir Howard Grubb will certainly be heartily congratulated by all who appreciate the difficulties to be surmounted.

For the movement in right ascension two slow motions are provided, namely, a comparatively coarse, slow motion of Sir Howard Grubb's ordinary type, consisting of differential wheels, and the other a very fine system of correction similar to that constituting the automatic clock control. The fine correction is operated electrically by a hand trigger, which is shown hanging from the eye end of the telescope, Figs. 3 and 4. The gear for setting the instrument in right ascension by hand, when detached from the driving clock, is shown by Fig. 2, this view also showing how all the driving arrangements are disposed within the frame of the instrument.

Figs. 3 and 4 are views to a larger scale of the eye end of the telescope, and show the arrangement for carrying the photographic plate, and also the manner in which the micrometer eye piece of the guiding telescope is mounted on a double slipping piece, so that it can be adjusted upon any star in the field which it is desired to use as the guiding point.—*Engineering.*

GALLS ON LIME.

THE galls are the work of a mite (Phytoptus tiliæ); generally no appreciable harm is done by them.—*The Gardeners' Chronicle.*

THE WHITE OAK.

OF the oaks which inhabit the New World, the white oak (*Quercus alba*) is most akin to the common and familiar tree of all European countries—the oak of myths and of poetry, of Dodona and Hercynia, the tree which Celt and Briton worshiped, which shaded the Druids' sacred fire, and has in all times been the emblem of strength and longevity. And here in America, when we think or speak in a general way of an oak tree, it is the white oak which naturally most often presents itself to the mind, as the leaves and fruit of this tree resemble more nearly than those of any of our other species the conventional oak leaves and acorns with which we have become familiar from childhood.

The American white oak is a noble tree. In girth of stem and stoutness of branches it is not second to its Old World relative; and there are very few American oaks which grow over such a wide stretch of country, or are so generally multiplied. The burr oak, perhaps, when it has grown under the most favorable conditions, produces timber which is stronger and more solid than that of the white oak, but there is no American oak which furnishes universally and over such large areas such a high quality of timber.

As it grows in the dense forests of the Allegheny Mountains, or of the valley of the lower Ohio, the white oak sends up a tall and massive stem destitute of branches to a height sometimes of sixty or eighty feet and crowned with a narrow head of comparatively small branches. In less favorable climates or on thinner soil it is a smaller tree, with a shorter trunk and larger branches, which extend laterally in proportion as the individual has found room for their development.

The white oak owes its name to the color of the bark, which is light gray or sometimes nearly white on vigorous trees, with a surface broken into long, narrow, rather thin scales. The character of the surface is the same on young and on old trees, and only varies slightly in color on different individuals, and, as it is unlike the bark of any other oak tree of eastern America, it furnishes the most ready means for distinguishing this tree at a glance at all seasons of the year. The inner

THE NAIL-GALL OF THE LIME.

FIG. 3.

FIG. 4.

EQUATORIAL PHOTOGRAPHIC TELESCOPE FOR THE MELBOURNE OBSERVATORY.

bark, as is the case with that of many other oaks, possesses astringent properties, and has found a place in our materia medica in the form of decoctions.

The wood of the white oak is very heavy, a cubic foot of dry wood of average quality weighing rather more than forty-six pounds; it is strong, hard, tough, and close grained. The annual layers of growth are marked by numerous rows of the open ducts present more or less in all oak wood. The broad and prominent medullary rays are silvery white, and make a handsome contrast with the light brown color of the body of the wood.

The leaves of the white oak when they first unfold are tinged with red and coated with silvery white tomentum. At this time, when the tree is covered also with its catkins of yellow flowers, the white oak presents a beautiful appearance in the forest, and is perhaps more distinct and attractive than at any other season of the year. As the leaves grow they lose their hairy covering, and at maturity are quite smooth. They are obovate oblong in general outline, and obliquely cut into three to nine obtuse, mostly entire lobes, which vary considerably on different trees in number and breadth and in the depth of the sinuses which separate them.

These sometimes penetrate nearly to the midrib, making the leaf appear almost pinnatifid. The leaves when fully grown are six or eight inches long by two or three broad, and are borne on stout petioles. Late in the autumn, after the leaves of many of the trees with which the white oak grows have begun to fall, they turn gradually first yellow and orange and then deep vinous red or sometimes bright scarlet. The brilliancy of their autumn coloring is retained for a long time, and, as the leaves die, they turn gradually brown and fall slowly, many remaining on the branches through the winter and until the buds of another year begin to open.

The sterile flowers, like those of our other oaks, are produced in slender, naked, hanging catkins, which are single, or often several together from the same lateral scaly bud. The male flower consists of a lobed yellow calyx and six to eight stamens with conspicuous yellow anthers. The female flowers, which are composed of a three-lobed sessile stigma and a three-celled ovary inclosed by a scaly budlike involucre which grows into the cup of the acorn, are solitary or clustered near the base of the shoots of the year. The fruit, like that of all the so-called white oaks, ripens at the end of the first season.

This character best distinguishes these trees from the so-called black oaks, which require two summers for the maturity of their fruit. The acorn when fully grown is sometimes an inch long, or often smaller at the north; it is slender, ovoid or oblong, chestnut brown, and inclosed for about one-third of its length in a pale, hemispherical, saucer-shaped cup, which is covered with tubercles at maturity. The fruit is sessile, or sometimes produced on slender stalks an inch or more long, the two forms appearing occasionally on the same tree, a peculiarity also of the Old World oak.

The white oak grows from northern Maine, Ontario, and the lower peninsula of Michigan to the shores of Tampa Bay, in Florida. It ranges west to western Missouri and Arkansas, and to the valley of the Brazos River, in Texas. In some parts of this great region it forms more than half of the forest growth. It is especially abundant in the group of States which contain the ranges of the southern Appalachian Mountains and in the valley of the middle portion of the Mississippi River. The white oak grows on nearly all soils except those saturated with stagnant water. It attains its greatest size on the rich lands of river bottoms, and produces in such situations its most valuable timber. Mr. Robert Ridgway, whose excellent observations upon the trees of the Lower Wabash and White River valleys, in Indiana, are published in the *Proceedings of the United States National Museum*, records the measurement of a number of white oaks produced on different soils. He found that the average trunk diameter of ten trees growing on bottom land was 4·59 feet, and that their average total height was 123·60 feet, while of seven trees growing on gravelly uplands in the same region the average trunk diameter was 2·40 feet, and the average total height only 99·82 feet.

The white oak was noticed by the earliest botanists who explored the North American flora. Bannister, the English minister, who died in Virginia, in 1692, knew it. Clayton, whose Virginia plants were published by Gronovius, remarked on the resemblance of its leaves to those of the English oak; and Catesby published in 1731, in his "Natural History of Carolina," the first portrait of the foliage and fruit of this tree. It is said to have been cultivated in England as early as 1724, and Michaux, late in the same century, sent great quantities of the acorns and young plants to enrich the forests of France. Such a valuable tree was naturally sought for by European planters, who a hundred years ago were keener than they are to-day in their search for exotic timber trees. Efforts to grow it successfully in Europe have, however, always failed; and a good specimen of this or of any of the other American species of the white oak group is probably not to be found there. The reason of this is not easily explained, for nearly all the black oaks, especially the red oak, the scarlet oak, and the pin oak, grow rapidly and live as long in Europe as they do in this country. Here the white oak, although it is a difficult tree to transplant, and is best grown from seed planted where the tree is to remain, grows very rapidly, and is one of the most desirable and ornamental of all our native trees for the embellishment of large parks and gardens.

The value of the white oak from an economic point of view is not easily overestimated. It supplies the principal part of the American oak of commerce, and is very largely used throughout the country in ship building, in all sorts of construction, in the manufacture of carriages and agricultural implements, for railway ties, fencing, cabinet making, the interior finish of buildings, and for cooperage, fuel, etc. For years it has been exported in immense quantities in the form of staves for wine and other casks, for which purpose there is a large and increasing demand for it in Europe and in California, where no oak furnishing wood suitable for this purpose grows. There are still great bodies of this timber standing in the United States, especially in western North and South Carolina and in eastern Tennessee and Kentucky and in Arkansas.

Railroads, however, are penetrating these oak forests, which inaccessibility has thus far preserved from the ax of the lumberman and the settler. Every year the supply is becoming less, and if it is fair to judge of the future of our forests by their past, white oak as a great forest product must eventually disappear. The time has already arrived when the white oak is worth preserving.

Few of our trees, indeed, better deserve care, especially as a danger more serious even than the ax is threatening to exterminate the white oak in the very region where it grows naturally in the greatest abundance. The acorns of this tree, like those of the other oaks with annual fructification, are, unfortunately, sweet, and are, therefore, hunted for and devoured by the hogs which are allowed to roam at will in great bands through the forests of the Southern States. They eat the white oak acorns and pass by the bitter fruit of the black oaks, which are, therefore, gradually getting possession of the soil and driving out more valuable species, so that it will be a question of time only, if the pasturage of the Southern forests is continued, when their most valuable tree will disappear.

The density of the original forest covering of eastern America prevented, except in rare cases, the growth of broad-branched, spreading trees such as we so much admire in some of the old forests and parks of England. There are exceptions however, and fine old wide-spreading white oaks are occasionally met with in the Eastern States. Such trees are those at Waverly, in Massachusetts, which have already appeared in this journal, and such is the tree growing on the grounds of Mr. W. H. Fearing, near Jobstown, New Jersey. The diameter of the trunk is six feet at three feet from the ground, and the branches cover a circle 120 feet across. Larger trunks are not uncommon, but such a magnificent expanse of foliage is rare. The tree is fortunate, too, in having escaped mutilation by wind and storm. It has lost no large limbs, shows no dead or dying wood, and is in vigorous health. Altogether the tree is a fine example of what the white oak can become under favorable conditions, and what character of trees the people who inhabit America three or four hundred years hence will have before their eyes if the present generation of planters plant wisely, and their descendants value trees for what they are worth and bestow upon them the care they deserve.—*Garden and Forest.*

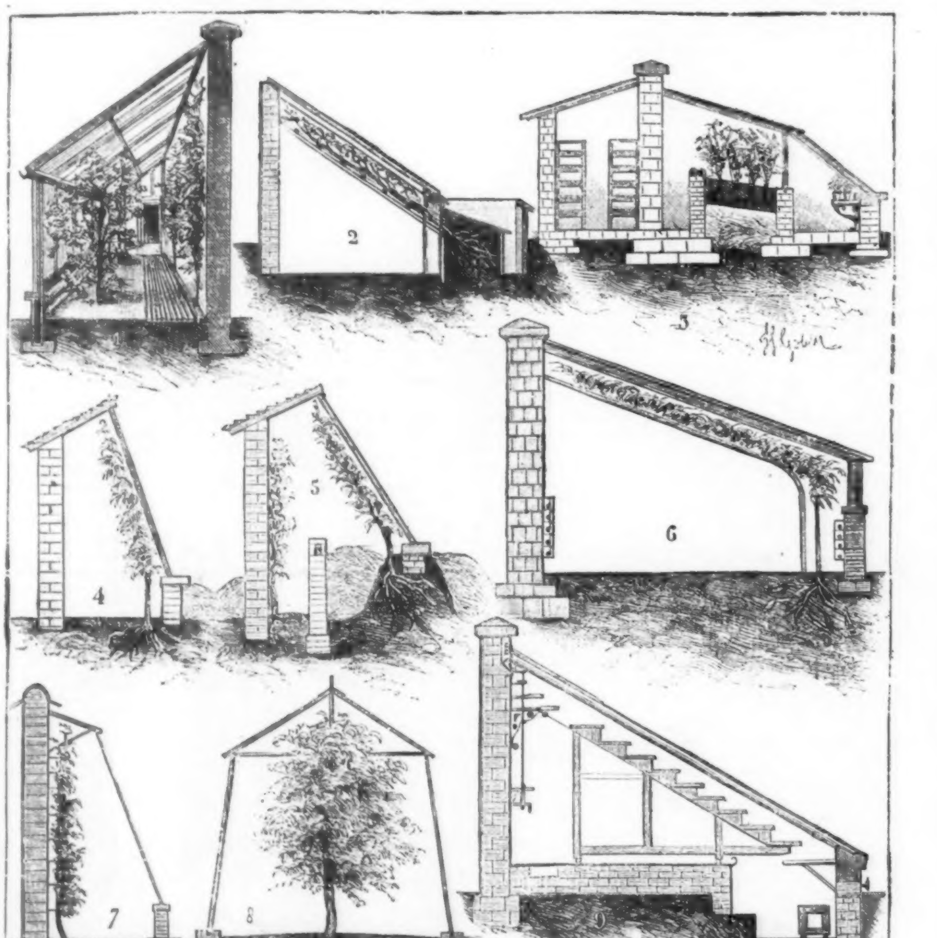


FIG. 1.—HOUSES FOR FRUIT CULTURE.

1. English hothouse for the culture of the fig. 2. Dutch hotbed frame for forcing the apricot. 3. Strawberry hothouse. 4. Peach house for the first season. 5. Peach house for the second and third seasons. 6. Great peach house of the royal garden at Frogmore. 7. Belgian cold house. 8. German cold house for stone-fruits. 9. Strawberry house of the German emperor's garden, at Potsdam.

CULTURE OF FRUIT TREES UNDER GLASS.

WE have recently studied the manner in which the English practice the artificial culture of the grape, and we have pointed out the matchless results that have been reached by our neighbors, as well as by the cultivators of Roubaix and Bailleul, in France, who have imitated them. But it is not only the grapevine that is cultivated under glass, for a certain number of shrubs, and even fruit trees properly so called, are in some countries exceptionally forced in this manner by those who wish to obtain fruits far out of the season of their habitual maturity.

All epochs, however, are not auspicious for bringing about this artificial modification of the vegetative season of fruit trees.

As a rule it is necessary in the first place to allow plants to have a certain amount of rest in order the better to force them. We are then certain of making them flower and of obtaining a crop of fruit from them. In nature, this period of rest is furnished them by our winters, and when no rest exists for certain plants (for the grapevine in tropical countries, for example), all that is obtained is an abundant production of sterile shoots of no utility.

Air, light and moisture, including the heat necessary to bring about vegetative activity, are also essential elements for developing in fruits (the peach and apricot among others) the bouquet and savor that particularly distinguish them. If, instead of obtaining them ripe in greenhouses in April, thanks to intelligent care (which, however, does not always succeed in obtaining them in as savory and well colored a state as in summer), we could bring them to maturity in the midst of winter, while the sun is wan and the days are extremely short, we should have nothing but insipid fruit, of no account.

In production under glass, it is expedient to distinguish forced culture in the hot house, culture in the cold house under glass, and retarded culture. The most important of these is the first.

In hot house culture the trees are either grown as in nature or trained to an espalier, parallel with the glass and 12 or 15 in. from it, and very rarely in pots. The form of the house is that of the ordinary hot house, but it is evidently necessary that the plants shall not be too far away from the light. They are usually lean-to structures and their roof presents but a single slope. They are oriented from east to west, so that they are exposed to the midday sun. The inclination of their sashes, besides, is so graduated that the sun strikes them at right angles at the time of flowering. The walls should be plastered in order to prevent insects from hiding in the cavities and subsequently attacking the fruit, and they should be whitewashed once a year. The glass used should be very thick, and, finally (a detail which is of importance), the forcing houses should always be provided with gutters for carrying off rain and snow water, the latter being capable of causing the crop to fail by cooling the earth at the base of the trees.

Here, for example (Fig. 1, No. 1), we have a model of an English hot house for the forced culture of the fig tree.

This installation is one of those that are most frequently met with in Great Britain. The model that we here give belongs to the house of Weeks & Co., of Chelsea. A temperature of from 17° to 18° is kept up in it during the day, and of from 12° to 14° during the night. No shading is ever done, even when the sun sends the thermometer up to 22° or 23°, but air is admitted every time the solar rays strike the glass directly.

As a general thing, the forcing is not begun till January. A good deal of irrigating is then done with liquid fertilizer made tepid with warm water. Then, when the fruit is about attaining its normal size,

nothing but pure water is used, and that in limited quantity.

In Holland, they have a very peculiar method of forcing another shrub, the apricot, by means of a hotbed frame and layers of manure. We give a section of one of these frames in Fig. 1 (No. 2). It is a wooden structure about 8 ft. in width. The apricot, when planted early (at the end of October), can be forced the same year, provided that its roots have been treated with care. Later on, in November, when the fibrils are already formed, there would be a danger of a late flowering and of having a large number of flowers that would abort, the transplanted trees being then obliged to form their fibrils a second time and to make a double consumption of elaborated sap.

These trees are always from six to seven years old. At every transplantation the roots that are too large are lopped off, and the trees are treated to a good dressing of vegetable mould. The potting is done from March up to the following winter in quite a light earth, covered with manure and moistened every fortnight with liquid manure.

In Fig. 1, No. 3, we have another model of a hot house, designed for the culture of the strawberry; it is that of the royal kitchen garden of Munich. Excellent strawberries are gathered from it in winter. Mushrooms are cultivated in the front part, and above are the strawberry plants in pots. The plants are spaced about 30 inches apart. They are set in light earth in the spring. Care is taken to water them very little in summer, in order that they may not develop too rapidly, and they are prevented from fruiting. In autumn the radical shoots are seen to flower, the fruit forms very quickly, the house is heated to about 18°, and in the following month a supply of strawberries begins that lasts to beyond the month of January. It is necessary to select for this purpose the erect varieties. Were it desired to have fruit for the middle of March, it would be necessary, toward the middle of December, to force certain special kinds, such as the Holland, with large red fruit, the Falstaff, the Chili, etc.

Of the berry fruits, we may mention, among the number of those cultivated in hot houses, the well known currant and gooseberry. The plants should be at least five years old to be potted. If the forcing is done early, the transplanting takes place a year in advance. If it does not take place till February, the potting may be done at the end of October. For potting, it is necessary to select the moment at which the plants are forming their fibrils before winter. They are then set in light and substantial earth, and are provided from time to time with liquid fertilizer. During the summer season, in order to prevent them from fruiting, it suffices to give but little shade. About a third of the woody branches is cut back in August, and the first plants are introduced into the hot house at the end of December. In spring, the temperature being from 5 to 6 degrees, the plants come into leaf. After fecundation, the temperature is raised, in measure as the maturation proceeds, up to 18°, and four months after the beginning of the forcing, fully mature fruit is obtained. After the leaves have once developed, the manuring should always be very abundant, except during the period in which the flowers are expanded. Much air should always be given, while, at the same time, a sufficiently moist atmosphere is maintained in the house.

Among the stone-fruit trees, the one most cultivated is the peach, whose fruit, after that of the grapevine, is considered the best for exploiting artificially from a commercial point of view. In the culture of this tree, there are distinguished three seasons, or, in other words, three epochs during which the plant is capable of furnishing its fruit for consumption. The peach of the first season, then, is that obtained in a hot house and the forcing of which has been begun as soon as possible at the end of November, in most cases, and which has reached maturity at the end of April or the beginning of May. The fruits of later crops raised in hot houses set in operation toward the end of January or February are designated as those of the second or third season.

In Fig. 1, No. 4, we have a section of a peach house for the first season, heated by a thermosiphon. This kind of a hot house has generally but a single pitch, because the trees (as shown in the engraving) have to be planted therein in such a way that they shall be as close to the glass as possible. In this model the front wall is not more than 12 or 14 inches in height, and is built upon arches, so as to permit the roots to develop more freely. This house is more especially adapted for elevated situations, and in light mould, dry rather than moist. Further along (Fig. 1, No. 5) we give a section of a peach house for the third season. This is heated by a smoke conduit. A layer of manure that covers the soil at the base of the trees helps also to maintain a proper temperature therein.

As a specimen of how things are done in England, we give (Fig. 1, No. 6) a section of the great peach house of the Royal Garden of Frogmore, near Windsor. This hot house is immense. It is about 16 feet wide and is divided into six compartments each 60 feet in length. In each of these, separated by partitions, there are four peach trees trained in the form of a fan parallel with the glass.

The peach trees employed for forcing are grafts one or two years old, well provided with roots. The planting is done at the end of October, for the chevelure begins to renew itself with the beginning of autumn. The trees are taken up without an adhering ball of earth in sandy soil, and with a ball when the soil is a little more consistent, care being taken in both cases to preserve all the roots intact.

The earth employed in the hot house is a compound of two parts of garden loam, one part of leaf mould, one part of well spent cowdung mould, and one quarter of coarse sand.

Among the plants cultivated in the hot house we may mention also the black mulberry.

Along with hot houses we have also mentioned cold houses.

The object of these is not so much to obtain an early crop, but to obtain the crop at a certain and regular epoch by protecting the trees against the pernicious influences of cold, rain, and high winds, in concentrating, at the same time, the solar heat necessary for the maturation of the fruits. The habitual luxuriant flowering of the peach and apricot trees, notably, obviously proves the influence of inclement weather, for in most cases the hopes that this apparent fertility give are not realized. Cold houses are now to be found in the gardens of a large number of amateurs. We give an example of them in Fig. 1, No. 7. The glass roof here is formed of two rows of sashes surrounding an espalier, and one of which is placed slantingly at a distance of eight feet from the latter, while the other, which connects the wall with the slanting sashes, rests upon a frame which serves likewise as a support to the upper part of the latter. This form of a cold house is especially used in Belgium. In Germany, for certain stone fruits, especially for plums and cherries, they use a different system, which we represent in Fig. 1, No. 8. The trees are here placed in glass structures some time before the flowers begin to expand, and in most cases a very abundant crop is obtained.

One of the most curious cold houses that we have met with was one in Germany, constructed for strawberry plants. It is represented in Fig. 1, No. 9. The model here given was observed in the gardens of the emperor at Potsdam. In this house we see a series of rising shelves upon which are to be placed the plants in pots, and which move, through small wheels, upon rails. Heat conduits permit of giving the interior the proper temperature, and ventilation is effected through openings easily regulated by means of a winch. The position indicated in the figure is that of the shelves as they are ordinarily placed, but when one proceeds to the cares of culture and watering which is to be done from the front, the shelves are pushed back near the wall.

Alongside of the culture of forced or early fruits, and of culture in the cold house, we may place the art of prolonging the season of certain fruits, or what we have, in other words, called retarded culture. This is of almost as great an importance as the two others, for it is that which produces those fruits that are less savory, but of indisputably pleasing aspect, that are offered late in the season at the epochs of hunting and of the entertainments given by wealthy families.

The peach, for example, is difficult to cultivate in this way in the open air. But the most certain way of succeeding is pot culture in an ordinary hot house properly lighted and aired. We shall have a few words to say about this process, which is adapted, moreover, for advanced culture. We then obtain splendid results.

For the pottings there are selected one-year-old plants that are to be obtained from all nurserymen, and, by preference, shoots 16 inches in height that have been nipped in the first year of their development. These are placed in pots 12 inches in diameter. Later on, after several repottings, larger pottings may be used, and trees trained into pyramidal form may be obtained that are capable of yielding as many as 60 peaches per year. These peach trees are grafted upon the St. Julien plum. Nos. 1 and 2 of Fig. 3 represent two types. The first, taken from a photograph of a tree cultivated in the Rivers establishment, is a bushy nectarine, three years of age, bearing twelve fruits. The second, photographed from a pyramid of four years' culture in Mr. Puis' model garden, at Gard, is a nectarine bearing 45 fruits. The varieties suitable for culture in pots are very numerous.

The apricot, which supports with difficulty the confined air of the hot house, is quite rarely cultivated in pots. The cherry, which is considered the most intractable of fruit trees for forced culture, gives good results in pots, provided there be sufficient aeration. Certain amateurs even find that the cherries ripen better in the hot house than in the open air, and that they possess more sugar and fragrance. The treatment is the same as for the apricot, and the most advantageous form to give the plants is the bush form and the pyramid.

The raspberry bush is likewise adapted for pot culture. It is especially the "Perpetual" variety with large yellow fruit and the same variety with large red fruit that seem best adapted to it. There is nothing more easy in the latter end of the season than to prolong the crop until December by transferring a few raspberry bushes in full production to a temperate greenhouse. In order to obtain good results, it is necessary to give the plants much light, and consequently to place them as near the glass as possible.

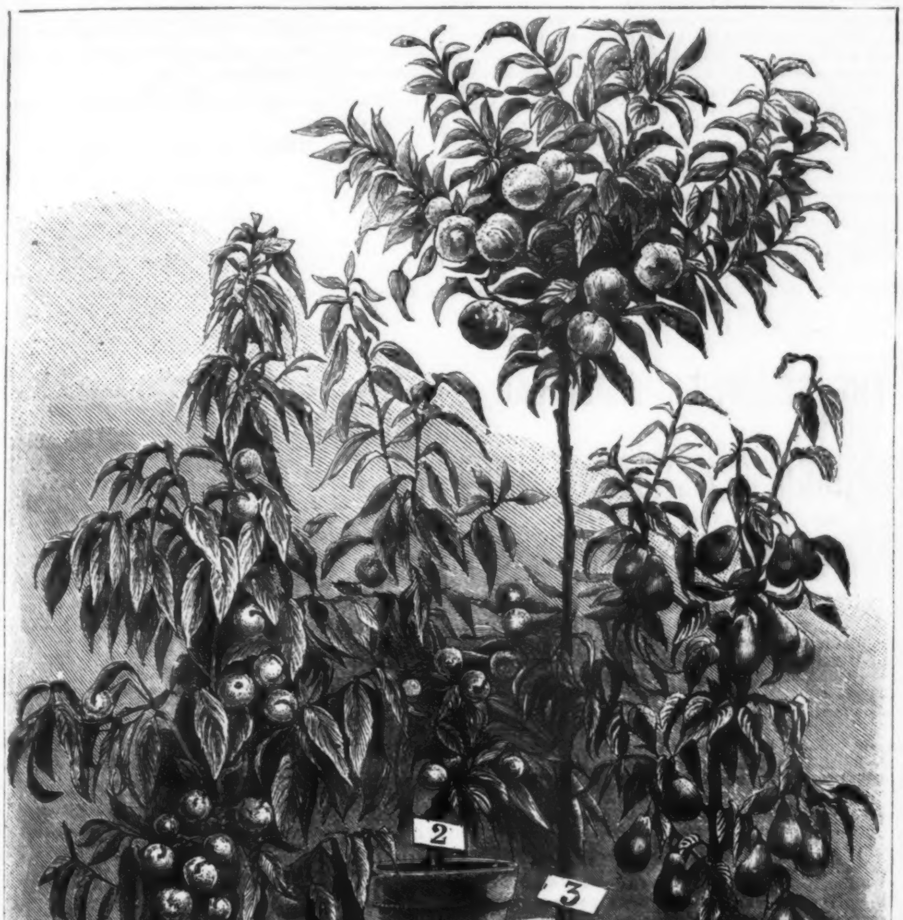


FIG. 2.—SPECIMENS OF FRUITS CULTIVATED IN THE HOTHOUSE.

1. Nectarine cultivated in a pot. 2. Another specimen of the same. 3. Apple cultivated in a pot. 4. Pear cultivated in a pot.

One of the most pleasing of pot cultures is that of the pear tree; for young plants, two years old, grafted upon the quince and bearing buds, can be made to produce fruit in the very year that they were potted. To succeed in this, it is necessary that the planting shall have been done in the fall, and the plants have been allowed to remain in the greenhouse at least during the first part of their vegetation. Results are then obtained such that it is almost always necessary to thin out the fruit, so as not to exhaust the plant. Only six or eight fruits are left the first year, and 20 or 24 two or three years after if the plants are sufficiently vigorous. In Fig. 2, No. 4, we give a photograph of a Louise-Bonne pear cultivated in pots and bearing 16 fruits. The form to be given to the plants is a matter of indifference. The forms most employed are the spindle and pyramid.

The apple, too, is one of the trees most commonly cultivated in pots, either for advanced or retarded culture. In spring, the flowering of these species, when they are sheltered under a glass roof, is magnificent, and produces a very fine effect at the moment of the expanding of the corollas. If the fecundation has been able to take place without hinderance, the flowers flourish *en masse*, and it is absolutely necessary to proceed to thin them out. Fruits are obtained whose dimensions are often greater than those ordinarily obtained in the open air. In Fig. 2, No. 3, we give a photograph of a Calville apple in the second year of pot growth. The plants selected for potting should be well formed and be grafted on the wild apple.

As for the pear, that requires much manure, and the most satisfactory results will be obtained by short and repeated nipping. We here terminate our rapid glance at the artificial culture of fruit trees. It has been our desire to give an idea of the results that may be obtained, and that are being obtained notably outside of France, thanks to methods which are but little known, and which we hope will not eternally remain the appanage of the Belgians, English and Germans.—*A. Renouard, in La Nature.*

ACTION OF HYDROGEN GAS ON PIG, STEEL, AND IRON.

FROM a series of articles written by M. A. Lencanchez, in *La Metallurgie*, the following is taken:

In 1885 I made a series of investigations on the action of hydrogen gas on pig, steel and iron. In an article on the subject I treated, with all the developments contained in this interesting question, on the action of hydrogen on the sulphur contained in the metal, and showed that this gas at temperatures of about 800° to 1,200° continuously removes the sulphur in the form of hydrosulphuric acid. I operated on charges of 100 to 120 kilos. of pig, steel, and iron. The quantity of sulphur driven off from the metal is not very great, but the action is continued without interruption during eight or ten days, and I am even disposed to think that the removal of sulphur in the form of H_2S would last a much longer time, seeing that the metal being solid the action of the hydrogen is only exercised at the surface, and subsequently, owing to its porosity, by very slow filtration through the metal. Pure hydrogen gas obtained by the humid process costs 2 fr. per cubic meter, and, therefore, it cannot be utilized at this price by industry. I then tried water gas containing 43 per cent. of H and 46 per cent. of CO, and the results were the same. Lastly, I used the rich gas of the gasogene. This gasogene worked very regularly and showed me that the action of the gas, though only containing 18 per cent. of H and 27 per cent. of CO, had the same effect on the sulphur of the metal as the two preceding.

We may therefore conclude from these numerous experiments, lasting three months (by operations of eight to ten days each), that the gas from the gasogenes can practically replace pure hydrogen—that is to say, that gas at 1 to 2½ and 3 c. per cubic meter can replace gas at 2 fr. per cubic meter. This being fully demonstrated, I am able authoritatively to say that the reheating for pig, steel and iron can be carried out in an atmosphere of gas from the gasogene. But as this reheating did not seem to be better or cheaper than that hitherto performed by oxide of iron, there was no room to abandon the old process or the new. However, I discovered that the reheating by the gas of the gasogene rich in H, and containing one part of CO for three to four parts of H and CO, decarbureted the pig as well as the oxide of iron, and desulphurates it at the surface, which has permitted the welding of plates of Bessemer steel which before the reheating would not weld. This is an interesting fact for the manufacture of tubes of steel welded in the rolling mills. On the other hand, pieces of steel and malleable pig obtained by reheating in gas are much better at the surface and much less malformed than those reheated with oxide of iron, which is often scorified in contact with the pieces to be reheated. Lastly, I have found that the regularity of temperature during the six to eight days which a reheating lasts is of very great importance, and that it is preferable to heat the reheating furnace by gas with recuperated heat than by the flame of an ordinary furnace hearth, continually giving variations of temperature with jets of heat deforming the pieces. But these great practical advantages are not taken into serious consideration by those who are interested, at least hitherto, who say that they only operate on quantities too small to compensate for the expense of the installation of furnaces heated by gas from gasogenes. This being said, we are led to remark that certainly the gas H, of the gasogenes with rich gas, or special gasogenes for water gas, is sufficient to carry off at a high temperature the sulphur of the iron and the solid steel. It is this fact which leads to the inquiry whether the same gas passing through iron and cast steel would not be able between 1,800 and 2,000 degrees to carry off the sulphur of the metal as well as at the temperatures of 800 to 1,200 deg. If so, it would suffice to make the water gas and with the Bessemer after the completed refining. There would be nothing more to do than to cause a current of gas to pass through the cast metal superheated to a high temperature, for the hydrogen to carry off the sulphur in the form of H_2S, as above stated, which would be of the highest importance for obtaining weldable Bessemer steel, a thing which has not yet been obtained in a regular, certain, and commercially profitable manner. If, therefore, hydrogen at 2,000° drives off the sulphur from the metal, as well as at 1,000°, there would be no hesitation in disposing the Bessemer apparatus so as to pass through them at the close of the operation a current of dry gas during one to two minutes, or three at the most, containing from 18 to 43 per cent. of hydrogen. The final desulphurization of the metal would be obtained at a very moderate price, which would permit of the manufacture by the basic process of steel and cast metal as weldable as iron refined on the fining hearth or in the puddling furnace. With regard to the cost of establishment, it would vary between 50 and 100,000 fr. at the most in proportion to the importance of the steel works.

I bring the article to a close with these statements, which may be of value to metallurgy in the near or more distant future if hydrogen at 2,000 degrees will combine with sulphur as well as at 1,000 degrees, a point upon which I could not assure myself, not knowing of any experiment of this kind at a very high temperature.—*Chemical Trade Journal.*

THE St. Louis *Miller* thinks that the Farmers' Alliance scheme for the government to issue $1,000,000,000 in treasury notes to loan the people at a nominal rate of interest would ruin any country on the globe. It would make thousands upon thousands feel that they could depend upon the country for support, and the outcome would be a class of indolent, careless people, that would be a weight upon us as a people and a nation. It is only when men feel and know that they must work themselves out of difficulties and up to wealth or a competency that a healthy state of affairs can exist.

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